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June 1901

SCALE INSECTS OF IMPORTANCE

AND

LIST OF THE SPECIES IN NEW YORK STATE

BY

EPHRAIM PORTER FELT D.Sc.

State Entomologist

ALBANY

UNIVERSITY OF THE STATE OF NEW YORK

1901

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[1] A general account and bibliography of each is given.

SCALE INSECTS (DIASPINAE) OF IMPORTANCE

Ord. Hemiptera: Fam. Coccidae

INTRODUCTION

"There is no group of insects which is of greater interest to horticulturists today than that family which includes the creatures popularly known as 'scale insects' and 'mealy bugs.'" These words, written 20 years ago by Prof. Comstock, the first American to make a close study of the characters presented by the female scale insect, are still true. These insignificant animals attack almost every tree and shrub and many herbaceous plants, and certain species have caused serious injuries and, under favoring conditions, are capable of inflicting enormous losses on our nursery, orchard and greenhouse interests. Their minute size, resistance to insecticides and marvelous prolificacy render them formidable pests. Scientific men have awakened to the importance of this group, and scale insects are being studied as never before. Large numbers of new species have been characterized within the last five years, and many important biologic facts relating to this family have been ascertained.

Characteristics. The popular name, "scale insects," is truly descriptive of the species belonging to one subfamily, the Diaspinae, or armored scales, since the insects themselves are covered with a scale, a secretion usually beginning on the recently hatched young as a mass of white, cotton-like threads (pl. 1, fig. 3), which mats down and extends to form a shield-like covering for the tender insect (pl. 1, fig. 4). These forms are frequently known as bark lice, because most of the species are found on the bark of trees or shrubs, and it is a very good descriptive name. The scale insects, like all others belonging to the same class, originate from eggs. Sometimes the eggs are deposited under the scale (pl. 1, fig. 8) and remain unhatched over winter, or they may develop into young within the body of the female (pl. 3, fig. 10), and then the insect is called viviparous, or more strictly, ovoviviparous. The young in either case are minute creatures possessing six true legs, with good locomotive powers for such small beings, and provided with eyes and a pair of antennae or feelers. That is, they have the normal characteristics of very young insects. The secretion of the scale, which usually begins within a few days after the young hatch, is followed by remarkable changes. The eyes, antennae and legs disappear, and there results an animated, sucking, sac-like creature (pl. 1, fig. 10) with apparently no

other aim or power than the perpetuation of the species. This, in brief, is the story of the female scale. It is different with the opposite sex. The scale, usually of a different form, is secreted by the young (pl. 2, fig. 6), and the same process goes on till the second molt, and then rudiments of limbs, antennae and wings are developed, and later appears the minute two-winged creature (pl. 3, fig. 12), which forsakes its sheltering scale and looks for a mate. This tiny insect lost its appendages while living under the protecting scale, and in time developed others much more delicate and refined.

Other scale insects are not protected by a shield of excreted matter and cast skins as are those mentioned above. They vary much in general appearance and habits. Some live in galls, others, like Kermes, resemble and are frequently taken for galls, while still others may be found in ants nests. The soft, brown Lecaniums are among the most common unarmored scale insects, and they can usually be distinguished by their oval, somewhat hemispheric bodies. The more typical Coccidae are represented by the "mealy bug," Dactylopius longispinus Targ., and the elm bark louse, Gossyparia ulmi Geoff. The former is common in greenhouses and the latter is found in considerable numbers on elms in many cities and villages. Neither of these lose their appendages with the first molt, as do the armored scales, and they retain the power of locomotion to a certain extent, at least. Coccidae belonging to this group are usually covered with a whitish, protective excretion, which is, for example, cotton-like in Gossyparia and granular in the "mealy bug."

Number of species. The number of described species of scale insects is very large. A check list of the Coccidae of the world[1], published by Prof. T. D. A. Cockerell in 1896, lists over 800 species, and a supplement[2] to this adds over 300, making a total of about 1100. Some of these will doubtless prove to be varieties, but new species are constantly being added to the list. A most interesting study of the forms occurring in the state of Massachusetts has been prosecuted by George B. King, of Lawrence (Mass.), who has succeeded, by collecting and compiling, in bringing together a list of 110, aside from several unidentified, species of scale insects known to occur in that commonwealth. Compilation of earlier records and the aid generously given by other entomologists have made it possible to prepare a list of 78 species of scale insects known to occur in New York state (*see* p. 354). Many additions will doubtless be made to this list by farther collecting.

1 Illinois state laboratory of natural history. Bul. 1896, v. 4, art. 9.
2 " 1899, v. 5, art. 7.

Injuries. The harm done by scale insects is seldom appreciated till it is too late. The scales may be noticed on the bark in considerable numbers, but so long as the tree shows no marked injury, the majority of people are inclined to believe that but little harm has been done. They appear to overlook the fact that a tree, like a man, may put forth every possible effort to sustain itself and apparently succeed in doing so, only to collapse suddenly at the end. Every living scale insect, after it has become established, is an automatic pump drawing the vital fluids from the host plant through a slender, hair-like beak or proboscis (pl. 3, fig. 10). The amount insects are capable of abstracting in this way from a tree is truly surprising. I have repeatedly seen showers of honeydew falling from elms badly infested with the elm bark louse, the excretion being so copious as to keep the walk beneath wet even on good drying days. This abundant excretion is not seen in the case of the armored scales, like the species to be considered later, but the production of their firm, protective coverings, as well as the nutrition of the thousands of insects, must make an enormous draft on the infested tree. This is proved by the fact that not infrequently trees are unable to withstand the drain and succumb. The injury these species can inflict is in a measure directly proportional to their productivity. A moderately prolific species possessing the ability to develop several generations in a season is one to be feared, because under favoring conditions a much larger number of individuals might be produced than would be possible for a much more prolific species which was limited by nature to one generation annually. It is the same for one year as the relation existing between arithmetical and geometric progression. This is why the San José scale is so dangerous. It is not only moderately prolific, but it develops a number of generations in a season. It has been estimated that in one year in the latitude of Washington (D. C.) a single female might produce, all conditions such as food supply, etc. being favorable, the enormous number of 3,216,080,400 descendants.

Means of dispersal. This is an extremely important matter, particularly to the man whose trees are free from these pests. The period when any of the scale insects to be considered below can travel of their own free will is very limited and, excluding the males, which may be disregarded in this connection, they are wingless and their crawling powers by no means great. These scale insects depend almost entirely on some external agency to transport them even from tree to tree, unless the limbs interlock. It has been demonstrated by Prof. W. G. Johnson that the

young of the San José scale are carried short distances by a strong wind, and there is no reason why those of other species might not be conveyed in the same manner. Evidence of one kind and another has been accumulating to show that active young of the scale insects are carried by other insects, birds and animals from tree to tree. It is also well known that these forms are most readily transported long distances on young trees and plants. This means is by far the most important, and fortunately is the one most readily controlled. Methods of preventing this dissemination will be considered under an appropriate head after the discussion of several injurious forms.

Certain species of value. Some Coccidae, or scale insects, are of economic importance on account of their products. The well-known cochineal is derived from the dried bodies of a scale insect, Coccus cacti Linn., which, as is well known, lives on several species of Cactaceae in Mexico. Prof. Comstock states that this insect is also reared in India, Spain and other countries. This species or a closely allied form is found on wild cactus in Ceylon, as stated by Mr Green.[1] Another species, Tachardia lacca Ker., excretes the substance from which is made the "lac," or shellac, of commerce, and from the insect itself a crimson pigment known as "lake" is obtained. This insect lives on species of Ficus and on Croton lacciferum. Prof. Comstock has described two American species belonging to this genus, Tachardia larreae and T. mexicana. The former occurs on the creosote plant, Larrea mexicana, a plant growing in the southwestern part of the United States and in Mexico, and in Prof. Comstock's opinion this "lac" insect might prove of economic importance. The latter species was found on a twig of mimosa from Tampico (Mex.) It is interesting to record that Prof. Cockerell has subsequently described four other American species of this genus. The waxy excretion of a Chinese scale insect, Ericerus pela Westw. is used in the manufacture of candles in that country. A near relative of our Gossyparia ulmi Geoff., the Gossyparia mannifera Hardw., "is found upon Tamarix mannifera Ehr., a large tree growing upon Mt Sinai, the young shoots of which are covered with the females, which, puncturing them with their proboscis, cause them to discharge a great quantity of a gummy secretion, which quickly hardens and drops from the tree, when it is collected by the natives, who regard it as the real manna of the Israelites."[2]

1 Green, E. E. Coccidae of Ceylon. 1899. p. 3.
2 Westwood, J. O. Introduction to the modern classification of insects. 2:449.

Recognition of scale insects. The majority of farmers and fruit-growers experience great difficulty in distinguishing between the various forms, and such will continue to be the case for some time to come; but it is hoped that the illustrations accompanying this account will enable the non-scientific man to identify certain of these vexatious forms with some approach to accuracy. It must ever be borne in mind, however, that, in attempting to identify an armored scale insect by external appearances, we are not studying the insect itself but a secretion subject to considerable variation as a result of climatic and other external influences. Scale insects occurring on trees near a railroad or in a smoky locality may have their characteristic appearance much obscured by particles of soot and dirt, and those living on trees infested to a considerable extent with plant lice or other honeydew-excreting forms, may be more or less covered with a sticky layer of dirt. These variations in appearance and the minuteness of scale insects render their correct determination very difficult for one who has not given the group special study.

Key based on superficial characters of species treated. The above statement regarding the variability in the appearance of the scales of these insects must be constantly borne in mind, and identifications made in this manner, unless by an expert, should be regarded as provisional. An effort should be made to secure both young and full-grown specimens and, if possible, on different pieces of bark, some having few and others having numerous individuals, as this will give a better idea of the characteristics of the insect. A good magnifying glass or lens should be used in examining the scales. A very serviceable one can be obtained for from one to several dollars, and it is invaluable to the nurseryman and fruit-grower in enabling him to examine suspicious appearances more closely. The characters given below do not apply to any of the oval, usually somewhat hemispheric brown species of Lecanium, but only to the species of armored scale insects treated of in detail.

The species briefly characterized below are arranged in the order of their present abundance in New York state; and, if the description in the first paragraph does not apply, pass to the second and so continue. It may frequently happen that the specimen does not agree with the descriptions given in any of the paragraphs, and in that case it is most probably one of the species not treated, of which there are many; and the way to ascertain the identity of such an insect is to send specimens to an entomologist.

1 Adult female scales elongated, slender, pear-shaped, usually slightly curved, almost $\frac{1}{8}$ inch long and brown. Numerous white eggs may be

found beneath the scales in winter. Occurs on many trees and shrubs. (pl. 1)

Appletree bark louse, Mytilaspis pomorum

2 Adult female scales irregularly expanding from a slender tip, about $\frac{1}{10}$ inch long and white or a dirty white. Purplish eggs may be found under the scales in winter. Male scales slender, white, with three ribs. Common on fruit trees and shrubs. (pl. 2)

Scurfy bark louse, Chionaspis furfura

3 Adult female scales circular or oval, usually a dark gray to black, about $\frac{1}{12}$ inch in diameter, and with the brick red cast skin or exuviae to one side of the center. Margin of the scale usually well defined. The young scales remain white or pink for a considerable time and usually have a well developed nipple and an inconspicuous ring. Very common in New York state. On fruit and other trees, specially maple and elm. (pl. 5)

Putnam's scale insect, Aspidiotus ancylus

4 Adult female scales circular, gray or yellowish gray, about $\frac{1}{16}$ inch in diameter and with the yellowish cast skin or exuviae central. Young scales dark gray, sometimes almost black, with a distinct central nipple and a grayish ring. Green tissues are frequently stained purplish by this insect. May occur on many trees and shrubs. (pl. 3)

San José scale insect, Aspidiotus perniciosus

5 Adult female scales nearly circular, usually a gray or a dark gray, with a diameter of $\frac{1}{8}$ inch and with the yellowish or red cast skin or exuviae a little to one side of the center. The gray, dirt-spotted, outer portion of the scale is usually continuous with the outer layer of rough bark, but this does not hold on smooth bark. The young scales are white or brownish and have a distinct nipple but almost no ring. They are sometimes arranged very prettily at almost equal distances. Occurs on fruit trees, specially plums. (pl. 4)

European fruit scale insect, Aspidiotus ostreaeformis

6 Adult female scales nearly circular, usually a yellowish gray, about $\frac{1}{12}$ inch in diameter and with the yellowish larval skin or exuviae a little to one side of the middle. Young scales white or pinkish, with the nipple and ring, specially the latter, not well marked. Occurs on fruit trees. (pl. 6)

Cherry scale insect, Aspidiotus forbesi

7 Adult female scales nearly circular, almost white, about $\frac{1}{12}$ inch in diameter and with the yellowish larval skin or exuviae a little to one side of the center. Young scales yellowish or white. Confined in New York state to greenhouse plants, common on ivy. (pl. 7)

White scale insect, Aspidiotus hederae

Appletree bark louse

Mytilaspis pomorum Bouché

PLATE 1

This is the most common scale insect found on fruit trees in New York, and in some localities it is very abundant and destructive, particularly to poplars and ash in the vicinity of Albany. This pest has been repeatedly noticed in agricultural and entomologic journals, and it is a frequent source of complaint at the present time. A few of the more important articles treating of this insect are given in the brief bibliography below. This European species was probably brought to America on early importations of fruit trees, and now it is known to occur all over the world, as stated by Dr L. O. Howard. It has been described scientifically several times, on each occasion receiving a different name, and it also passes under the common name of oyster shell bark louse. The popular designation given above is extensively used, and it is preferable on account of its being more characteristic of the species.

Description. The adult female scales can easily be recognized by a comparison with the greatly enlarged figure 7 or with figure 9, which latter represents a number in natural size on poplar bark. The adult scale is about 3 mm, or $\frac{1}{8}$ inch long, usually slightly curved and widening from a slender tip to a broad, rounded posterior end. The scale has at its pointed or anterior end a usually yellowish, very small pellicle, the first cast skin of the young, and a small scale three times its size attached to it. There is also a larger or second cast skin, and to it is attached the larger or chief part of the scale, which is a variable brown and marked with curved transverse lines or wrinkles. The first cast skin can be detected only on microscopic examination. The female insect found underneath the covering scale is represented in figure 10. The male scale is smaller, and is shown in figure 6. A female scale turned over in winter presents the appearance represented in figure 8. The shriveled, yellowish or brown body of the female occupies the anterior portion of the scale cavity, while in the posterior part are numerous oval, white eggs, shown greatly enlarged in figure 1. The minute, yellow, recently hatched scale insect is represented in figure 2, and the condition of a number shortly after establishing themselves on a twig, in figure 3. The appearance of the young after it has secreted a protecting scale is represented in figure 4, a few being shown much enlarged in figure 5.

Life history. This insect completes the round of life once a year in this latitude, though in the southern states two generations may be pro-

duced. The winter is passed in the egg under the protecting scale of the female, the young appearing from the middle of May to early June, and in the case of badly infested trees parts of the twigs may be literally yellow on account of the abundant crawling specks. Prof. Lowe has observed them as early as May 7 at Geneva (N. Y.) They soon settle in a place and begin sucking nourishment from the underlying bark tissues, and in about two days long, white, waxy filaments extend from the back of the young, and, where they are numerous, the infested branch is adorned with patches of woolly-appearing matter, as shown in figure 3. This excretion mats down and soon forms a protective covering. Close inspection shows this to be composed of a cast skin and a larger scale formed by the matted filaments adhering to it. Such half-grown insects, represented in figures 4 and 5, are about six weeks old. Another molt occurs later, and to this second cast skin a much larger scale is attached. The first cast skin and its scale are on top of the anterior part of the second, but are easily dislodged and therefore may not be observed. The fully developed female may be found beneath the larger scale about the first of August, egg-laying beginning soon and being completed by the latter part of the month or early September. One female deposits from about 50 to 100 eggs. Prof. Comstock states that, while he found the male scale rare on appletrees at Washington, it was abundant on other kinds of trees. The attacks of this insect are confined almost wholly to the bark, though there are a few records of the species occurring on fruit.

Food plants. This species is of greatest importance on account of its depredations on fruit trees, but it also occurs on a large number of other plants. The brief list of food plants brought together by Dr Lintner in his 11th report includes most of the more important species. It is as follows: apple, plum, pear, raspberry, wild cherry, wild gooseberry, red currant, sugar and swamp maples, white and black ash, birch, poplar, willows, linden, horse-chestnut, elm, etc. Dr L. O. Howard, writing of this insect in 1895, gives two lists of food plants, a number of which are not represented in the above enumeration, and he proceeds to state that, though no structural differences have been found between the forms on these varied food plants, he can hardly avoid the strong suspicion that certain of these will not interbreed, and that eventually distinguishing characteristics will be found to exist.

Natural enemies. A small hymenopterous maggot was observed by Dr Fitch to live on the eggs of this pest. What was in all probability the same parasite was described by Dr Le Baron some years later as Aphelin-

nus mytilaspidis, which he found had destroyed from about 50% to 60% of the scales. Aphelinus fuscipennis How. is recorded as a most efficient parasite of this scale in California. Aspidiotiphagus citrinus Craw. has been reared from this pest in that state. The accompanying figure will give a good idea of the appearance of these tiny Chalcids. The best evidence of their work is the small circular holes in the dead scales, orifices by which these little friends have escaped. Aphelinus abnormis How. is another parasite of this bark louse. Anaphes gracilis How. and Chiloneurus diaspidinarum How. have also been reared from this insect.

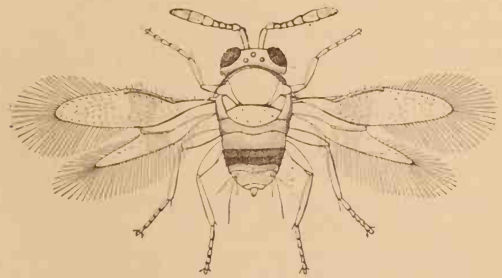

Fig. 1 Aspidiotiphagus citrinus Craw., greatly enlarged (After Howard. Insect life. 1894. 6 : 229)

Coccinellid or lady bug larvae prey on this species, and certain mites, Tyroglyphus malus Shimer, are also credited with this habit. A French investigator has apparently shown that this Tyroglyphus does not feed on the eggs, but a species is described, under the name of Hemisarcoptes coccisugus Lign., which does valiant service in destroying them.

Three European birds, the blue tit, the long-tailed tit and the tree creeper are known to feed on this insect.

Remedies. The hatching of the young the latter part of May or in early June renders it practicable to control this insect by applying a contact insecticide June 1 or later in order to kill the young scale insects before they are protected by a thick scale.

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Scurfy bark louse

Chionaspis furfura Fitch

PLATE 2

This common and destructive species is not an imported insect, like the preceding form, but the two occupy in New York state nearly the same rank as pests of considerable economic importance. The scurfy bark louse frequently appears in large numbers, specially on recently set fruit trees, which occasionally become so covered with the pest as to look at a little distance as if they had been whitewashed. Closer inspection shows the infested trees to be nearly covered with dirty white, scurf-like patches, and it is from this that the popular name of the insect has been derived.

Description. Sometimes this insect occurs in thick, matted, dirty masses, and then the form of the individuals is much obscured. There is usually some place on the infested plant where the females are somewhat isolated and have the general appearance represented in figure 7, which shows a group of females with two males in the lower right hand corner. A closer examination of one scale will reveal the details illustrated in figure 4. The female scale consists of a very small yellowish pellicle (usually two are present), a larger dark scale and a very much larger, irregularly shaped, whitish scale. Figure 1 shows this structure in greater detail. The male scales are elongated, with a small yellowish pellicle and a much larger, tricarinate white scale, as represented somewhat enlarged in figure 8 and much more so in figure 6. A rupture of a female scale in the fall or winter reveals the purplish eggs beneath (fig. 1), and, when one is turned over, the shrunken body of the parent and the mass of eggs is exposed (fig. 5). The active, reddish young is represented in figure 2, and the partly grown individuals, showing the yellowish pellicle and the dark smaller scale, in figure 3. The full-grown female, as she appears under the scale before egg deposition begins, is represented in figure 9.

The male was not reared, and, as a matter of fact, it is rarely observed. Prof. Comstock's description of this form is as follows:

Yellow marked, with irregular reddish-brown spots; thoracic band reddish brown, sometimes darker than the other markings. Length of body including style, .62 mm (.02 inch); length of style, .18 mm (.006 inch). On each side of the anterior part of the thorax there is a black spot which resembles an eye.

The accompanying illustration of the male and its pupa will aid greatly in its recognition.

Life history. The development of this species is very nearly the same as that of the preceding form. The winter is passed in the egg underneath the protecting scale of the female. The young appear in this latitude about the same time as do those of *Mytilaspis pomorum*, viz from about the middle to the last of May. They soon establish themselves at favorable points on the bark of the trunk and branches and begin drawing sustenance from the underlying tissues through the delicate, thread-like haustellum or beak. Occasionally the young may establish themselves in some numbers on fruit. Such a case was brought to notice this season. The insects were at the blossom and stem ends of the apples and each was surrounded by an irregular, reddish area. A considerable proportion of the fruit was infested in one orchard in

Greene county. The appearance of the insect about six weeks from birth is well shown in plate 2, figure 3. Then there are yellowish exuviae and a dark grayish scale about 1 mm or $\frac{1}{25}$ inch long. Later the conspicuous larger, white portion of the scale is excreted, and the eggs may

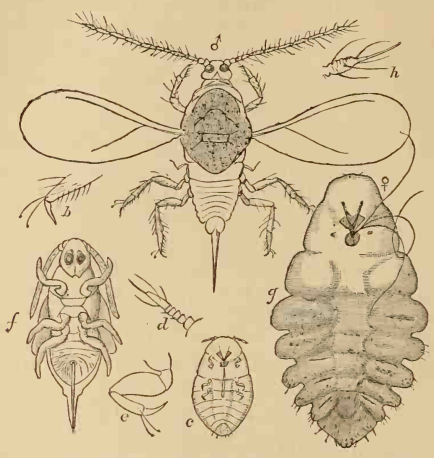

Fig. 2 Chionaspis furfura: Adult male above; *b* foot; *h* tip of antenna of same; *c* larva; *d* antenna; *e* leg of same; *f* pupa; *g* adult female removed from scale—all enlarged, *b*, *d*, *e*, *h* much more than the others. (After Howard. U. S. dep't agric. Yearbook. 1894)

be found the latter part of August or in early September to the number of 30–75 under one scale, where they remain dormant till the following spring. It is stated that two and possibly three generations may develop in one season in the southern states.

Food plants. This scale insect is specially abundant in New York on apple, pear, Japan quince and blackcap raspberry bushes. Dr Howard found it so numerous on mountain ash in the Catskill mountains, that hardly a twig or branch was uninfested. It has also been recorded on the following: crab apple, peach, quince, black cherry, choke cherry, wild red cherry, shad bush, cherry currant, wild flowering currant, black walnut and black alder (Clethra alnifolia). The identity of the insect on all these food plants has not been established beyond question. I have since learned that Mr King has succeeded in bringing the list up to 23 food plants; so this species can be classed as a general feeder.

Distribution. This insect is well distributed over New York state and is present in many other states, as shown by the following compiled list: Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Pennsylvania, Maryland, Virginia, West Virginia, District of Columbia, Kentucky, Tennessee, Georgia, Kansas, Mississippi, Ohio, Indiana, Illinois, Missouri, Iowa, Nebraska, Utah, South Dakota and California. It has also been recorded from Ontario, Nova Scotia, New Brunswick and Prince Edward Island. The absence of record by no means implies that the scale is not known in the omitted states. It has also been recorded from England, having been carried there on Ribes sanguineum. Dr Howard, in his account of this insect, alludes to

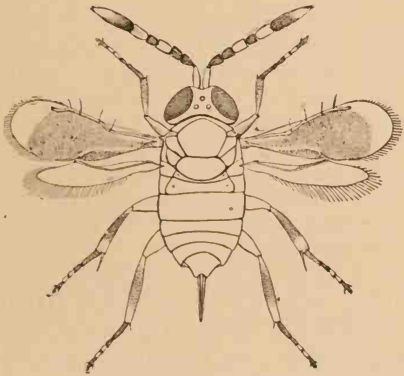

Fig. 3. Ablerus clisiocampae, female greatly enlarged. (After Howard, Insect life. 1894. 7:7)

an early record where it is stated that the appletree bark louse is gradually supplanting this pest, and proceeds to state that the former is apparently the hardier, and that he believes that it will in time take the place of Chionaspis furfura. Both species have been in New York state for about 50 years at least, and it does not appear that the native form has been materially checked by the presence of a more hardy rival.

Natural enemies. One hymenopterous parasite, Ablerus clisiocampae Ashm., has been bred from this scale insect by Dr Howard. Two Coccinellids, Hyperaspidius species and Chilocorus bivulnerus Muls., the twice stabbed lady bug, prey on this pest. The latter is stated to be a specially valuable enemy.

Remedies. The recommendations for controlling this insect are the same as those advised for the preceding form, to which the reader is referred.

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Pernicious or San José scale insect

Aspidiotus perniciosus Comstock

PLATE 3

This insect is known by hearsay, at least, to almost every fruit-grower and farmer in the eastern United States. It has recently become established in a number of widely separated localities in New York state, and is now the object of considerable anxiety to both horticulturists and nurserymen. This pest is very destructive in some of the more southern states, and even in New York, when allowed to increase without restriction, it causes considerable damage. Its ability to inflict so much injury

depends largely on its inconspicuousness and great prolificacy. So marked are these that several trees may be literally covered with the pest before the owner is aware of its presence, and this in spite of his being on the watch for the enemy.

Those who unfortunately have the insect on their premises find that it is a difficult pest to combat, and that only the most thorough work will produce the desired results. Carefulness to avoid this scale insect and a strong desire to learn about its appearance and life history, are ordinary precautions every fruit-grower should take, and this spirit should be encouraged wherever found. Ridiculing such precautions in an attempt to make light of the danger, and sensational statements regarding the destructiveness of the insect, are both to be deprecated. Neither the nursery nor the horticultural interests of New York state will be ruined by this pest, but those who neglect the proper precautions may suffer considerable loss. The ultimate result will be better care of many orchards and a more just appreciation of the powers for good or evil possessed by insects.

Destructiveness in New York state. Continuous fighting, even in this latitude, is the price of practical immunity from danger in places where the scale has become established. There are several orchards within 20 miles of Albany where this pest has been for the past eight to 10 years. Some trees have been killed outright, others ruined and many seriously dwarfed and stunted. The record would have been worse, had the pest not been fought, and, on the other hand, it might have been much better if recently discovered facts had been accessible earlier. I allude in particular to the value of petroleum, specially of the mechanical emulsion. There are a number of records of this pest doing little damage in a locality till some eight years after its establishment, and then suddenly with favoring conditions it may become very abundant and injurious. The possible rapidity with which this scale insect may increase in this state is strikingly shown by an apple twig 15 inches long of 1898 growth which on receipt at the end of that season was nearly covered with half-grown scales. That is, the pest was able to keep up with the rapidly growing tree, and at the end of the season a large proportion of the new wood was nearly covered with half-grown scale insects. G. G. Atwood, now in charge of the inspection work in the state informs me that he has repeatedly noticed that this pest thrives best on vigorous trees.

Indications of the presence of the scale. This scale insect is so minute that it has usually escaped the observation of any but specially trained eyes till it had become quite abundant. People are learning what

to look for now, and the pest is usually discovered earlier. Trees which have been badly infested for some time have a rough bark covered with dark gray, scurfy patches, and, if this be scratched with a knife or finger nail, an oily, yellowish substance will be crushed from the living insects under the scales. This insect breeds so rapidly that it is not uncommon to find large numbers on a tree previously comparatively free. In that event the bark may be literally covered with recently established scales and not appear very rough. There is, however, a peculiar, granular look, and those familiar with the bark of a rapidly growing tree are aware that some change has taken place. There is nothing like a good magnifier in these cases, and, if this shows hundreds of circular, black or dark gray objects, with dot and ring, or lighter gray, yellowish marked scales, send a sample of the bark to somebody competent to identify the trouble. Cutting into the bark under a San José scale is almost sure to reveal a reddish discoloration of the green tissues beneath. Lenticels occasionally deceive people, and I have seen fungous growths which at a little distance looked much like masses of young pernicious or San José scale. An infestation of any extent on fruiting trees is almost sure to show itself on the leaves and fruit, the reddish blotches being more conspicuous than the insects (fig. 3). The reddening of the fruit is not absolute proof that San José scale is present, because I have seen nearly the same effects produced by Chionaspis furfura Fitch. The pear illustrated shows a condition which obtains in badly infested orchards in July. Late in August the blossom end and sometimes the other may be literally incrusted with patches of young and old scales like the one represented in figure 7. A close examination of a slightly infested tree may result in finding a very few scales somewhere on the bark, most frequently near a bud or some protecting elevation, and, in these cases, the piece of infested bark should be cut away and sent to an entomologist for identification.

Description. This scale insect is so minute that a superficial description must be drawn in most general terms. The twig, fruit and leaf shown in figures 3, 4 and 5 of plate 3 represent a very characteristic appearance in July in a pear orchard badly infested by this pest. A dark grayish or yellowish area on the bark may be caused by a mass of these scales. An enlargement of the darker patches will show a condition much like that represented in figure 7. Adult, yellowish gray scales may be found surrounded by hundreds of tiny black ones. The form of the larger scales is modified somewhat by the degree of crowding, and it is common to find a number of them adhering in a patch; but a close examination of the well

marked adult female scale reveals the following characteristics. It is almost 2 mm, or $\frac{1}{8}$ inch, in diameter, nearly circular, grayish, with a central darker nipple surrounded by one or more rather well-defined yellowish rings (fig. 9). The smaller scales are nearly black, with a central nipple, and one or two grayish rings as represented in figure 13. The largest scales are just about the size of the head of an ordinary pin, while the smaller ones are mere dots, as represented by the black specks on the twig, figure 5. Sometimes the female scales have a distinct yellowish shade, as shown in figure 6. The yellow, usually somewhat kidney-shaped female insects may be found under the scales. A gravid female is shown much enlarged in figure 10. Note the oval young within her body and the slender proboscis apparently composed of two filaments but in reality of four. The yellow, active young is shown much enlarged in figure 11. The antennae, six legs and slender proboscis are all present. The young appear as minute specks when on the trees. They soon cover themselves with a white excretion, and then they appear like white dots surrounded by red, whenever they establish themselves on green fruit or bark (fig. 2). The form of the white scale and the colored area around it are represented in detail in figure 1.

The male scale may be easily recognized by its elongated shape with the nipple near one end (fig. 8). The delicate, two-winged male is represented much enlarged in figure 12.

Life history. The winter is passed by this insect in a partly grown, dormant condition. Vital activities are resumed with the approach of warm weather, and the first outward indications of life are seen in the appearance of winged males and later of the crawling young, the latter of which appear in this latitude toward the last of June. The life history of this insect has been studied in detail at Washington (D. C.) under the direction of Dr L. O. Howard; and from his account most of the following details are taken. The females continue to produce young for a period of about six weeks, each averaging about 400, or from nine to 10 every 24 hours. This is an ovoviviparous species. That is the eggs develop within the mother and the young are born alive. They may be seen as tiny yellow specks escaping from under the maternal scale, from which they wander in search of a favorable place to establish themselves. This pilgrimage occupies relatively few hours (an average of a little over $27\frac{3}{4}$ hours, according to Prof. Lowe), and the young soon establishes itself, works its slender proboscis through the bark and begins to draw nourishment from the plant. The development of the

scale begins, even before the young has selected its feeding place, as very minute, white, waxy filaments, which spring from all parts of the body, rapidly become thicker and slowly mat down to form the circular, white scale with a depressed ring and central elevation (pl. 3, fig. 5). This white scale gradually becomes darker, and in a few days it has assumed a black or dark gray color, with one or more lighter rings, as represented in plate 3, figure 13. The skin is cast for the first time 12 days after the young appear. The molt, as is true of all species of Aspidiotus, consists of a splitting of the old skin around the outer edge of the flattened insect, the upper part being attached to the scale and the lower portion forming a ventral scale next the bark. Prior to this molt the sexes are indistinguishable, and both lose legs and antennae at this time. The males may now be recognized by the large purple eyes and the elongate, pyriform body, while the females are eyeless, and are practically flattened sacs with only the slender, central sucking bristle. Six days later, or when the insect is 18 days old, the male molts to the pro-pupa (fig. *b*), and the male scale becomes an elongated oval in form. The antennae,

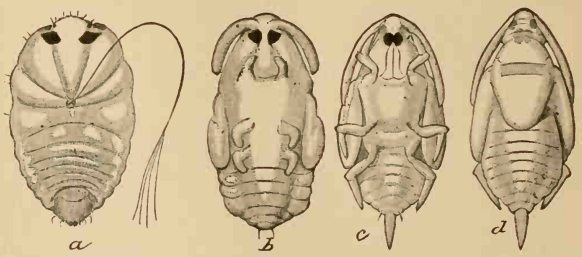

Fig. 4 Development of male insect, *a* ventral view of young after first molt, *b* same after second molt (pro-pupa stage), *c* and *d*, ventral and dorsal views of true pupa. (After Howard U. S. dep't agric. div. ent. Bul. 3, n. s. 1896)

legs and wings now appear in a very rudimentary condition and in two days become much better shaped, when the change to the true pupa (fig. *c*, *d*) takes place. Four to six days later, or from 24 to 26 days from birth, the mature, two-winged males back out from under their protecting scales. The female undergoes a second molt about 8 days after the first, or when she is about 20 days old, and 10 days later she is full-grown and within her transparent body (pl. 3, fig. 10) are seen partly developed young, which begin to appear in from three to 10 days later. Thus the round of life may be completed, as determined from a study of the

female, in from 33 to 40 days. The detailed studies made at Washington show that four full generations are developed normally in that latitude and that there may be a partial fifth. The production of a few young each day for some six weeks leads to a confusion of broods toward the end of the season, and their exact number can not be determined without special study. This insect breeds in the vicinity of Albany from the latter part of June through October. After making due allowance for the difference in latitude and the slower development in cooler weather, we can hardly expect more than three full generations normally, with a possibility of a fourth under exceptionally favorable conditions. This is confirmed by the studies of Prof. V. H. Lowe at Geneva. He found the average duration of the period of growth to be 49½ days, which gives just about time enough for three full generations during the growing season.

Food plants. This insect has been recorded on a considerable number of food plants, and its ability to live on so many varieties adds very much to the difficulty of exterminating or controlling it. The following is a list of food plants, as compiled by Dr Lintner, with a few additions by Dr Howard and from office records.

Tiliaceae
- Linden

Celastraceae
- Euonymus

Rosaceae
- Almond
- Peach
- Apricot
- Plum
- Cherry
- Spiraea
- Raspberry
- Rose
- Hawthorn
- Cotoneaster
- Pear
- Apple
- Quince
- Flowering quince

Saxifragaceae
- Gooseberry

Saxifragaceae (*continued*)
- Currant
- Flowering currant

Ebenaceae
- Persimmon

Leguminoseae
- Acacia

Oleaceae
- Lilac

Urticaceae
- Elm
- Osage orange

Juglandaceae
- English walnut
- Pecan

Betulaceae
- Alder?

Salicaceae
- Weeping willow
- Laurel-leaved willow (from Asia)

The state of New York has for the last three years maintained a corps of inspectors for the purpose of examining all nursery stock for the presence of this and other injurious pests. Many exceedingly valuable facts have been gained in this manner, and the following comments on the food plants of the San José scale in New York state by G. G. Atwood, now in immediate charge of this work, are based on considerable experience. The plants are grouped in three sections.

1 This list of plants on which this scale is not found, although in proximity to infested plants, includes all evergreens and as follows, viz: ailanthus, althea, amaryllis, American ivy, anemone, aspen, azalea, barberry, Boston ivy, buckthorn, beech, butternut, buttonwood, catalpa, chestnut, cherry (black tartarian), chionanthus, clethra, corylus, currant (black), cranberry, deutzia, elder, elm (American), euonymus, exochorda, forsythia, ginkgo, hydrangea, Judas tree, halesia, hickory, Kentucky coffee tree, laburnum, larch, liquidambar, locust, magnolia, maples (sugar, Norway, ash leaf and Japan), matrimony vine, mulberry, oak, paeonia tree, philadelphus (mock orange), plum (wild goose), privet, rhododendron, silver thorn, snowball, spiraeas (some species), sycamore (plane tree), tamarix, tulip tree, viburnum, weigela, wistaria, xanthoceras and yellowwood.

2 The following is a list of plants on which the San José scale has been found, though in very small quantity, and no injury has resulted from its presence, and it is probable that it will not live over winter on them in this state, and it is not likely to breed freely on them: alder, amalanchier, ash, birch, blackberry, chestnut, dewberry, dogwood (flowering), elaeagnus, eucalyptus, fig, grape, honeysuckle, horse-chestnut, kerria, maples (silver and wiers), milkweed, mountain laurel, peppergrass, poplars (except aspen), quack grass, quince (edible), raspberry, rhus, spiraeas (some species), strawberries, walnut (English), and to this list I would add cherry commonly called "sour," including such varieties as Richmond, Morello, etc.

3 The following is a list of plants on which the San José scale finds suitable food, and therefore spreads rapidly, causing serious injury: acacia, akebia, apple, peach, pear, plum, cherry (sweet), apricot, nectarine, almond (flowering), cherry (flowering, Rocky mountain dwarf and Japan), cotoneaster, crataegus, currants (red, white and flowering), elm (English), gooseberry, Japan quince, mountain ash, peach (flowering), prunes (flowering and pissardi), Osage orange, snowberry and willow (many species).

It is noticed that this latter list is not very long, but unfortunately it includes the principal orchard trees and currants. In some sections it looks as if the San José would not thrive on Kieffer pears, while elsewhere it proves very destructive to this variety.

Distribution. This pest is widely distributed in the United States, having been recorded from 36 states and territories, besides the District of Columbia. It has also been found in a number of localities in Ontario (Can.)

This insect has gained a secure footing in New York state, as is shown by its having been found at one time or another in 29 of the 61 counties. The known infested localities are limited in many cases to one or two in a county. There has been no thorough survey of the bearing trees of the state; and, when that is made, many other infested orchards may be discovered, though it is hoped that such may not prove to be the case. It is quite important for the owner to know if his trees be infested with this pest; and therefore every fruit-grower is urged to send any twigs or fruit, which present a suspicious appearance, to an entomologist for examination.

Original home. There has been considerable written regarding this matter; and it now looks as if proof would shortly be forthcoming to show that this species is a native of Japan, a country considered by several who have given the subject attention, to be most probably its home. The evidence brought forward up to August 1899 failed to convince either Dr Howard or his colaborer, Dr Marlatt, that the pernicious or San José scale is a native of Japan, they holding that, so far as evidence is concerned, there was nothing to prove that the insect did not come to us from China, from some other portion of eastern Asia or possibly from some of the islands in the Pacific or from Australia. A recent note by Prof. V. L. Kellogg states that S. I. Kuwana, assistant in entomology at Stanford university, spent last summer in a systematic investigation of Japanese Coccidae and in the course of his work he found that the San José scale was distributed over the whole Japanese empire, it being in certain regions a serious pest. The note also states that Mr Kuwana "finds much evidence to uphold the belief that the insect is native to Japan." This announcement does not settle the question, but it looks as if Japan might prove to be the original home of the pest.

Natural enemies. A number of true parasites have been reared from this scale insect. Anaphes gracilis How. was obtained from infested twigs taken in Charles county (Md.) and Aspidiotiphagus citrinus Craw. was reared from the San José scale in California. Aphelinus mytilaspidis Le Baron and A. fuscipennis How. have been reared from scales taken in a number of localities in Maryland by Prof. W. G. Johnson. The latter species was bred in large numbers by Prof. Johnson and promises to become an important aid in controlling this pest.

A very small black lady bug, Pentilia misella Lec., an American species which feeds on the San José scale, was found by me in con-

siderable numbers in an infested orchard near Albany. The beetle, in its various stages, is represented in the accompanying figure. It is quite convex in shape and only $\frac{1}{16}$ of an inch long. The twice stabbed lady bug, Chilocorus bivulnerus Muls., is another native form known to feed on this pest. The beetle may be recognized by its jet black color relieved by two red spots on its wing covers. Several lady

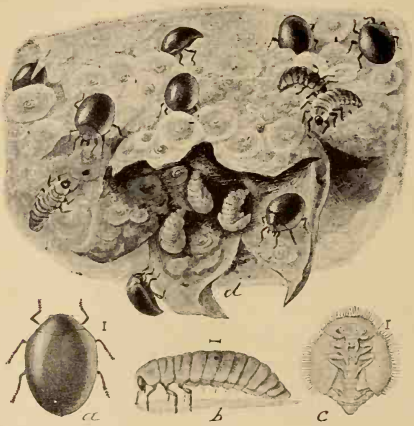

Fig. 5 Pentilia miscella *a* beetle; *b* larva; *c* pupa; *d* blossom end of pear showing scales with larvae of Pentilia feeding on them, and pupae of Pentilia attached within the calyx—all greatly enlarged. (After Howard, U. S. dep't. agric. div. ent. Bul. 3, n. s. 1896)

bugs introduced into California were colonized on trees infested with San José scale, and of these, three have since been discovered feeding on the pest. They are Orcus chalybeus, O. australasiae and Scymnus lophanthae.

A fungus disease, Sphaerostilbe coccophila Tul., attacks this pest, and in some localities it has killed a considerable number of the scales. Prof. P. H. Rolfs credits this organism with practically exterminating the pernicious scale in one Florida orchard and with reducing by considerable the numbers of the pest in others. It is undoubtedly a native of Florida, as it is very common on Aspidiotus obscurus Comst. This fungus was cultivated, and new colonies of scales infested, but unfortunately, like other fungi it is very dependent on favorable

climatic conditions, and this limits its usefulness seriously. Fungus-infested scales were sent to other states, and the disease was at least temporarily established in several places. After the fungus has consumed the insect, an orange colored protuberance forms at the base of the scale or breaks through it, but, as this is only from $\frac{1}{40}$ to $\frac{1}{8}$ of an inch in hight, it is not very apparent.

Necessity and value of certificates of inspection. The present New York state law compels the inspection of all nursery stock by the commissioner of agriculture or his agents at least once a year prior to September 1; and, if the stock is found to be apparently free from dangerously injurious insects and from contagious diseases, the commissioner is required to issue a certificate stating the facts. A nursery found infested must be cleared of the scale before a certificate of freedom from pests can be granted. It is unlawful to ship any nursery stock by public carriers unless each car, box, bale or package be accompanied by such a certificate dated within a year. All transportation companies are now required by law to notify the state commissioner of agriculture whenever any nursery stock is received from any point without the state. This provision was made to aid in preventing the introduction of infested nursery stock from other states.

The value of a certificate depends much on the manner in which the inspection is conducted. That issued by our state department of agriculture represents faithful, close work, and it may be accepted as conclusive evidence that the trees are apparently free from this pest. Occasionally a few trees with the scale on them and accompanied by the commissioner's certificate have been received in other states; but I am not aware that any proof has ever been advanced to show that the infested trees were actually inspected in New York state, and in one or two instances it does not appear that the nursery stock was even sent from a point in this state. A certificate from a reliable party may be accepted as presumptive evidence of the freedom of the stock from this scale insect. It should not, however, prevent the buyer from scrutinizing the trees most closely and fumigating them, if they have not already been so treated.

Means of dispersal. These are limited, as pointed out in the general introduction, very largely to conveyance by other animals or by the elements. The young may crawl from tree to tree where branches interlock, they are blown some distance by prevailing winds, and the insect is also carried on young trees. Prof. Webster, in Ohio agricultural

experiment station bulletin 81, records an instance where this insect spread from an infested tree up a gully with the prevailing winds, while it made no progress in the opposite direction. This insect, in badly infested orchards, is frequently found in considerable numbers on the fruit, and in such cases the adult females may be producing numbers of young daily in the early fall. There is no record known to me of distribution of the San José scale by means of infested fruit, but such is a source of danger to adjacent orchards, where it may be carried or thrown by careless boys or men; and, if it is put on the market and sold in an uninfested locality, it may result in the introduction of the scale there. All that is necessary is that such fruit with bearing females be left close to a suitable food plant. This danger should be guarded against so far as practicable.

Careful investigations by the officials connected with the United States department of agriculture at Washington have shown that there is not the slightest danger of living San José scales being carried on dried fruits, as the drying is fatal to the insects.

Preventives of attack. The most effectual and in most cases the most practical method of preventing injury by this insect lies in excluding it from the orchard. There are even now localities in Long Island where the infestation of adjacent trees is bound to nullify any attempt to exclude this pest. Exclusion is possible, however, in most places in the state. A fruit-grower's first care should be to admit to his premises no trees or shrubs of any kind that may harbor this or other dangerous insects. The inspection of nurseries of New York state has done much to render difficult the sale of stock infested with this scale insect; but there is always a chance that some infested trees may be received by a dealer from outside, become mixed with that pronounced clean by the inspector and sold as such, and there is also a small possibility that once in a while a few infested trees may escape the inspector's eye. There have been several cases in this state where a very few of these scale insects must have lived on trees supposed to be clean for three to five years, at the end of which time it was suddenly found that they were badly infested with the pest. These facts are exceedingly strong arguments in favor of buying only stock that has been thoroughly fumigated by hydrocyanic acid gas, as this treatment is the best safeguard against the occasional scale insect.

Not only is it necessary to prevent the actual introduction of scale-intested stock in the orchard or on the farm, but the fruit-grower will soon

find it of advantage, so far as possible, so to locate his orchards as to reduce to a minimum the danger of this and other insect pests being conveyed by natural agents from adjacent orchards to his own. A man can never tell what pests a neighbor may unfortunately have in his orchard, or in a long series of years just how much care that orchard may receive. It is therefore good business to have valuable orchards somewhat isolated; and, if one man be fortunate enough to possess several, it would be well to have them somewhat separated and thus offer a serious obstacle to the spread of this or other pests from one orchard to another. A row of evergreen trees between adjacent orchards would probably prove of considerable service in preventing the carriage of scale and other insects from one orchard to another.

Possibility of extermination. There is no one at all familiar with the conditions, who expects to see New York state eventually freed from this pest. It is beyond the possibilities. The insect may be eradicated from certain places where it has not gained much of a foothold, but, as a general rule, it is very doubtful that the pest will be cleared from any locality where it has become even fairly established, because people will not ordinarily adopt the radical measures necessary to exterminate it. There are records of the insect having been exterminated from limited localities, but this line of work is advisable only where the infestation is comparatively recent, the area where the pest occurs sharply defined and distant from other infested trees or shrubs. Exclusion is the most promising method of protecting an orchard and next to that the adoption of methods for keeping the insect within moderate bounds. Because there has been difficulty in controlling this pest, it need not be assumed that such will always be the case. This insect is no longer greatly feared in certain parts of California, and the indications are most favorable for the finding of a practicable method of controlling the insect in the eastern United States.

Method of extermination. Dig up by the roots every infested tree and others at all likely to have this scale insect on them and burn them at once, unless this work be done in the late fall, when it may be advisable to allow the uprooted trees to lie in a pile till about June 1 before burning, in order to permit the escape of any beneficial parasites which may be present. Digging up by the roots is quite important because a few scale insects may be found on portions of the tree below the surface of the ground. A less radical method would be to destroy the infested trees as described above and to treat the suspected ones most thoroughly

in early spring with whale oil soap, mechanical petroleum emulsion or with hydrocyanic acid gas, the latter being the most efficient.

Remedial measures. These will be considered in detail under a separate head, special attention being given to the pernicious, or San José scale.

Bibliography

This scale insect has attracted more attention than any other injurious insect; and in these days of easy and rapid publication the notices regarding it have accumulated at a remarkable rate. The attention of the student is called particularly to the accounts and bibliographies by Dr Lintner, Dr Howard and his associate, Dr Marlatt, to which the appended bibliography is largely supplemental. A few of the most important notices cited by the above named writers have been repeated, and special attention has been given to the more important articles concerning this insect in New York state. No attempt has been made to include a mass of minor notices relating to this pest in other parts of the country or in other countries.

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European fruit scale insect

Aspidiotus ostreaeformis Curtis

PLATE 4

This species has been in New York state probably much longer than the pernicious, or San José scale and yet it is a comparatively unknown insect to farmers and fruit-growers. This form was first received at the United States department of agriculture in 1895 from Dr Peter Collier, then director of the experiment station at Geneva. It was erroneously referred to one of the allied species, no one at the time suspecting its foreign origin. The systematic inspection of nurseries in the state, begun in 1898, resulted in finding much more of this scale insect. G. G. Atwood, then of Geneva, and a nursery inspector, had the fullest oppor-

tunity for learning of the distribution of this species. The original infestation was probably in an orchard in Geneva propagated from cuttings imported some 30 years ago. All other places in the state, so far as was ascertained by Mr Atwood, had received buds or cuttings from this orchard. So it seems most probable that this insect has been established in the state about 30 years.

A European pest. This species is stated by Dr Marlatt to be a well-known pest on various fruit trees in Europe. He is of the opinion that, were it as actively exploited in this country as has been its close relative, the pernicious or San José scale, it would assume a similar importance. It is undoubtedly a species which should be carefully watched, but its behavior in the state of New York up to the present does not justify the expectation that it will ever in this latitude rank in importance with the closely allied Aspidiotus perniciosus. Mr Atwood in a letter dated Ap. 4, 1899, states that in no case was serious injury evident. I have received some pieces of bark pretty badly infested with this species, but the average shows fewer insects than is the case with trees infested with the pernicious scale insect. This form seems to be more injurious in Pennsylvania, as some nursery stock badly infested with this species has been received from there.

Description. The general appearance of this species is similar to that of the pernicious, or San José scale. The white stage is shown in figure 1. A quite characteristic appearance of the young of this species is shown natural size in figure 2 and enlarged in figure 3. The sides of the scale are dark gray, while the center which is nearly white, may be grayish or brown. The young appear to have quite a habit of arranging themselves at nearly equal distances from one another. The white or brown portion of the adult scale may break away and expose the yellowish cast skin or exuviae, as is shown in figures 4 and 5. A number of scales are represented natural size in figure 6 and a portion enlarged in figure 7. Some of the young are always found among a mass of old scales, and, when they are white, the gray of the old scales is lightened considerably. Sometimes masses of this scale insect are a dark gray, and then the young are usually grayish or brownish. The individual adult female scale may attain a diameter of nearly $\frac{1}{8}$ inch. It has a yellowish or orange nipple a little to one side of the center, and the gray part of the scale is normally marked with black specks (*see* fig. 9), and, when on a rough tree, the edge of the scale is usually continuous with the outer layer of the bark. The male scale (fig. 8) is somewhat oval in outline.

The female insect as removed from under a scale is represented in fig. 10, and one of her yellowish progeny in fig. 11.

Life history. The winter is passed by partly grown individuals which become mature toward the last of June. This insect, like the pernicious scale, is ovoviviparous, that is, gives birth to living young, which begin to appear about the last of the month and continue to emerge for several weeks. This species produces but one generation in this latitude, and this restriction alone makes it much less dangerous than the preceding form.

Food plants. This insect appears to have a decided preference for plum in New York state, since it is most frequently found on this fruit tree. It has also been found on apple, pear, cherry, prune, currant, purple-leaved plum, mountain ash, elm, linden, Carolina poplar and willow.

Distribution. This insect has become established in widely separated localities in America. It has been reported from the following states: Ohio, Michigan, Iowa, Idaho, Kansas, and it has been received from Pennsylvania. Dr Marlatt records its presence at several Ontario (Can.) localities, and in British Columbia.

This species is now widely distributed in the state, having been received from Fredonia, Chautauqua co., Lewiston and Youngstown, Niagara co., Brighton, Penfield and Rochester, Monroe co., Geneva and Stanley, Ontario co., Williamson, Wayne co., near Kinderhook, Columbia co. and Millbrook, Dutchess co. It has been received by Dr Howard from Trumansburg, Tompkins co., Grooms, Saratoga co., Troy, Rensselaer co., Fishkill, Dutchess co. and Blauvelt, Rockland co.

Remedies. Methods of value against the pernicious or San José scale should prove equally effective with this species, and as a rule it will probably be found much easier to control.

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Putnam's scale insect

Aspidiotus ancylus Putnam

PLATE 5

This is the most common native species of Aspidiotus found on fruit trees and shrubs in New York state. Occasionally it may occur in such large numbers as to be somewhat destructive, but ordinarily natural agents of one kind or another keep it in check. Mr Cooley records a case in Massachusetts where nearly every tree in a young apple orchard was infested, some abundantly, and one was dying from the attacks of this species. This record is very exceptional, at least for New York state, though I have seen it very abundant on currant.

Description. This species is of importance largely because of the liability of its being mistaken for the much more dangerous, pernicious, or San José scale. It is distinguished with difficulty by external characters from the preceding species. A twig badly infested with Putnam's scale has a dark gray or almost black color relieved here and there by the reddish, eccentric larval skins or exuviae. There are few or none of

the whitish remnants of young scales, as frequently seen in the European fruit scale before the insects are disturbed by abrasion of any kind. The young scales of this species may be almost white or pinkish, as shown in figures 1–4, their edges are sharply defined, the dot and ring are present, but there is rarely the oval, white nipple surrounded by a grayish, specked scale almost continuous with the bark, as in the European fruit scale; neither are the young as dark, nor as flattened as are those of the pernicious scale. The half-grown young have the appearance represented in figure 5. The adult female scales, which are about $\frac{1}{12}$ inch in diameter, are shown natural size in a mass in figure 6 and more enlarged in figure 7, which latter also represents a rather characteristic shape of this scale when it occurs in masses. Figure 9 illustrates a female scale as it may develop when comparatively isolated. A rather irregular male scale is represented in figure 8. The adult female and the active young are shown very much enlarged in figures 10 and 11.

Life history. This insect, like the preceding, passes the winter in a partly grown, though usually more mature, condition. There is but a single generation. The studies of Mr Putnam, in Iowa, show that the males appear there the latter part of April, and that the female deposits from 30 to 40 eggs in the late spring or early summer. The crawling young of this species may be seen during most of July, in the latitude of Albany, indicating that the hatching of the eggs extends over a considerable period. Prof. Johnson states that this species may cause a purplish tinge in green tissue, but it is not so marked as with the San José scale. I have not observed this discoloration in New York state.

Food plants. This species has been recorded on a number of plants. Prof. Comstock has found it on ash, beech, bladdernut, hackberry, linden, maple, oak, Osage orange, peach, and water locust. Dr Lintner has received it on apple and red currant—on the latter it is sometimes very abundant, and he has also seen it on olive, evidently from a greenhouse at Jamaica (L. I.) It has also been recorded on cherry, plum, elm and willow. Prof. Johnson attributes the killing of an English oak in Illinois to this scale insect. It has been received from this state by Dr Howard on pin oak and hemlock. It also occurs on mountain ash, pear, nectarine, Ilex verticillata, Ilex laevigata, white birch, Prunus, American elm and on hawthorn in West Virginia.

Distribution. This insect has been recorded from the following states, Kansas, Iowa, Michigan, and New York, and from Washington (D. C.) R. A. Cooley found it to be one of the most common species in

Massachusetts, which is also true of it in this state. That it is one of our commonest species of Aspidiotus on fruit trees is shown by its being the most numerous of those found by Dr Reh on fruit imported into Germany from America (*see* Bibliography). It has been received from the following localities, a portion of which were kindly communicated by Dr Howard: Palmyra, Wayne co., Brighton, Monroe co., Medina, Orleans co., Geneva and Stanley, Ontario co., Waterloo, Seneca co., Ithaca, Tompkins co., Benton, Yates co., Germantown, Columbia co., Ellenville, Ulster co., Glen Cove, Nassau co., Blauvelt, Rockland co., Flushing, Far Rockaway and Jamaica, Queens co., and Brooklyn. It occurs commonly about Albany.

Natural enemies. A minute chalcid parasite, Coccophagus varicornis How., was reared from this species by Prof. Comstock.

Remedies. This insect can be checked, when necessary, by spraying with the insecticides and in the manner recommended for the San José scale.

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Cherry scale insect

Aspidiotus forbesi Johnson

PLATE 6

This species is the rarest in New York state of those noticed in detail in this bulletin. It has been known to science but five years, having been described by Prof. W. G. Johnson in 1896.

Previous history. Prof. Johnson characterized this species as the most dangerous scale insect then established in Illinois. It was first discovered on Morello cherry, and later he found that it was generally distributed over the state. It also occurred on wild cherry, and, on account of its apparent partiality for that tree, the above common name was proposed. Prof. Johnson states that it was not uncommon in 1896 to find seven and eight year old cherry trees literally covered with the pest, and that a number were killed by it. Prof. Forbes, state entomologist of Illinois, writing of this and allied species in 1898, states that "they are of no extraordinary interest to the fruit growers, none of them being either as abundant or as destructive when present as the commonest of the native orchard scales, the so called scurfy scale of the apple, Chionaspis furfura". It will probably prove no more injurious in this state than in Illinois.

Description. This scale insect is closely allied to the three preceding forms. Its rarity in the state has prevented a thorough study of its external characteristics. A mass of the adult scales, so far as observed by me, is much lighter in color than that of either of the two preceding species and usually lighter than a similar mass of San José scale, because the latter is almost sure to include a number of the dark gray or nearly black young. The general appearance of an infested twig is shown in figure 6, and a group from this is enlarged in figure 7. The adult female scales are rather flat, yellowish gray, and about $\frac{1}{12}$ inch in diameter and with a reddish, eccentric larval skin or exuviae. The color and general appearance is well shown in figure 7 and in greater detail in figure 8,

which represents the scale of a fully developed female. The form and orange red exuviae of the male scales are illustrated in figure 9. The varying appearance of the young is shown in figures 3, 4 and 5.

Life history. This species, as determined by Prof. Johnson, winters partly grown in Illinois, the males appearing about the middle of April and the young beginning to emerge early in May, eggs and young being found as late as June 20. This insect, in the latitude of Springfield (Ill.) produces two generations annually, the males of the second brood appearing from July 10 to August 1, and the young of this generation from the first week in August till late in September.

Distribution. Prof. Johnson states that this insect is common in Illinois and neighboring states. It is apparently very rare in New York state, having been received from Manchester, Cornwall and Kinderhook and by Dr Howard from Geneva. So far as known, it has been found in but two localities in Massachusetts. Prof. Hunter records it from Kansas and New Mexico. It also occurs in Maryland, Georgia and West Virginia.

Natural enemies. The following seven parasites were reared by Prof. Johnson from this scale insect: Prospalta murtfeldti How., Prospalta aurantii How., Perrisopterus pulchellus How., Signiphora nigrita How. MS., Arrhenophagus chionaspidis Aur., Ablerus clisiocampae Ashm., and a species belonging to the genus Encyrtus. He also observed whitish mites under the scales. The twice stabbed lady bug, Chilocorus bivulnerus Muls., in both adult and larval stages, feeds on this insect.

Food plants. This insect has been recorded on the following: apple, apricot, cherry, pear, plum, quince, currant and honey locust.

Remedies. Thorough spraying with insecticides, as recommended for the San José scale, should prove equally effective with this species.

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White scale insect of the ivy

Aspidiotus hederae Vallot

PLATE 7

This species is rather common in greenhouses in the state, and not infrequently it causes considerable damage, specially to ivy, its favorite food plant. The ivy is not always killed, but the white scales on the dark green leaves render it unsalable. Large quantities of this foliage plant have been rendered worthless in this manner.

Description. Infested plants may be recognized by the white, irregular patches of scale insects. An examination of one of these under a lens will show it to be composed of a number of yellowish-white, circular scales, each with a deeper yellow cast skin, or exuviae, a little to one side of the center. The appearance of an infested spray of ivy is well shown in figure 7. The large, yellowish-white scales are usually surrounded by a number of small white ones. Such a group is represented much enlarged in figure 6, and a full-grown female scale, which is about $\frac{1}{12}$ inch in diameter, more enlarged in figure 4, while a young white scale is shown very greatly enlarged in figure 3. Some of the yellowish, active young can usually be found on an infested leaf. One is shown much enlarged in figure 2. The removal of an adult scale may uncover a yellowish female, represented in figure 1, or there may be found only her shriveled remains, shown greatly magnified in figure 5, and possibly a few very minute yellowish eggs and one or two active young (fig. 8).

Life history. The conditions in the greenhouse usually permit this insect to breed continuously, so that there is no demarcation of broods. Adult females, half-grown individuals and crawling young can usually be found at almost any time. This insect lives outdoors in the southern states, and, under these conditions, Prof. Comstock is of the opinion that there are at least two generations annually. He bred adult males in April from specimens received both from California and Florida, but I have been unable to find a sign of this sex on a badly infested ivy plant kept under observation for some months. This species is apparently both oviparous and ovoviviparous. I have observed eggs and living young besides empty egg shells under female scales, and Mr Coquillett states that he has witnessed the birth of living young.

Distribution. This is a well-known European species which has a wide distribution, having been recorded from such distant places as Australia, Chile and Cuba. It has attained a general distribution in the

United States. It is known to be present in a number of widely separated localities in New York state, and it will probably be found in greater or less numbers wherever greenhouse plants have been grown for some years.

Food plants. This pest is able to subsist on a number of different plants. Prof. Comstock has studied it on acacia, magnolia, oleander, maple, yucca, plum, cherry, currant and the china-tree, Melia azedarach, in California and on ivy at Ithaca (N. Y.) He also found it on grass and clover growing in pots with infested trees and on lemons from the Mediterranean and from California. Prof. Morgan states that it is very abundant on the "china-tree" in Louisiana. It is recorded as a pest of the olive in countries where that tree grows. Prof. Johnson states that it is particularly destructive in Maryland to Asparagus plumosus, the so-called lace fern. D. W. Coquillett records it in California on the following additional plants: lilac, arbor vitae, century plant or aloe, oak, Quercus agrifolia, and nightshade, Solanum douglasii. It has also been collected in Albany greenhouses on Areca lutescens, Cyperus, Kentia belmoreana and Strelitzia reginae.

Natural enemies. Prof. Morgan reports rearing a hymenopterous parasite from this scale insect, and Mr Coquillett states that the imported Australian lady bug, Rhizobius debilis Blackb., feeds on this species in California.

Preventives and remedies. It is comparatively easy to control this insect in New York state, since it can not live outdoors. It can be kept in check by spraying or washing the infested plants with whale oil soap solution (1 pound to about 5 gallons), kerosene emulsion (diluted with 12 parts of water, *see* p. 339) or an ivory soap solution (a 5 cent cake of the latter to 8 gallons of water). These substances will hardly do more than keep this insect in check, and repeated applications will be necessary. It will be much more satisfactory, as a rule, to clean the greenhouse thoroughly in the summer and then stock up with clean plants.

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Remedial measures against armored scale insects

The recommendations on the following pages are based very largely on experiences with the pernicious, or San José scale, and in a number of cases they are advised only for that insect. Measures found effective against this pest can hardly fail to give satisfactory results when used under similar conditions against the other species treated. The experience of the last few years has demonstrated that in certain sections of this state nothing but continuous fighting will prevent serious damage to orchards infested by the pernicious, or San José scale.

Only contact insecticides of value. It hardly seems necessary to dwell on this subject. It is quite well understood that scale insects draw their sustenance from the underlying plant tissues through a slender proboscis or haustellum. This method of feeding renders it impossible to kill the pests by using paris green or other stomach or internal poisons. The only way to get at these creatures is to apply to them some substance which will kill by contact, and even this, in the case of the armored scales and some others, is difficult on account of the protective covering which may shield the insect to a considerable extent. There are plenty of substances which will kill these pests, but the difficulty is to find something which will not at the same time injure the tree. The cost of material and its effect on the apparatus employed must also be considered.

Whale oil soap. The winter or early spring treatment for the pernicious, or San José scale appears to be the most effectual and satisfactory. The infested trees should first of all be trimmed back severely. This not only economizes in the amount of material necessary, but renders it possible to give more effectual treatment. Thorough spraying with a potash whale oil soap solution, using 2 pounds to a gallon of water and applying it just before the buds open, will check this pest severely and will not injure the trees. This treatment is perfectly safe, and, if thoroughly carried out, quite satisfactory, but, judging from our experience, it can not be relied on to kill all the scales. It should prove equally effective against the allied species of Aspidiotus. It is

quite essential to have a potash soap that does not contain more than 30% of water. Such a soap can be secured in large quantities at from 3½c to 4c a pound, thus making the mixture cost 7 to 8c a gallon. Soda soaps are difficult to apply in winter on account of the solution being gelatinous when cold. Experiments with both Good's and Leggett's whale oil soaps gave little or no difference in their insecticidal value. Good's soap dissolved much easier and was less difficult to spray.

Whale oil soap and crude petroleum combination. Experiments with a combination of whale oil soap and crude petroleum, did not give as good results as were obtained with a plain 20% crude petroleum emulsion. This compound was obtained by dissolving a pound of whale oil soap in each 4 gallons of water and putting the mixture in the barrel of a "kerowater" sprayer.[1] Crude petroleum was placed in a tank and the pump set to deliver 10% oil, thus obtaining a whale oil, petroleum emulsion.

Crude petroleum emulsion. Treatment of the pernicious or San José scale in early spring with a 20% mechanical emulsion of crude petroleum, using a "kerowater" sprayer, was found even more satisfactory than the whale oil soap solutions, and so far it appears not to have injured the trees in the slightest degree. The petroleum used was the blended product sold by the Standard oil co. as crude petroleum. It is said to run about 44° on the Beaumé oil scale, but a sample of the oil used gave a reading of but 37° while some purchased in December 1900 stood at 41.5°. It was tested in 1900 both in an experimental and in a practical way with most excellent results. There is less danger of injuring the trees if a lighter oil is used and it is apparently just as effective as an insecticide. W. H. Hart of Poughkeepsie (N. Y.) obtained most excellent results on a large scale with a mechanical dilution of crude petroleum purchased of the Frank oil co., Titusville (Pa.). This oil runs from a little above 43° to nearly 45° on the Beaumé oil scale. The mechanical emulsion does not change the nature of the oil, but it enables the operator to cover a tree thoroughly with a minimum amount, and thus there is not only a saving of material but there is less danger of injuring the tree. The crude petroleum spreads readily, adheres to the bark in spite of repeated rains, leaving a glossy coat of the heavier oils, which remains

[1]Made by the Gould manufacturing co., Senaca Falls N. Y. Mechanical sprayers are also made by other manufacturers. It is well to test them when working from time to time by turning the spray into a jar, allowing the oil and water to separate and then to measure the amounts of each.

moist and distinctly visible for several months, and this residuum undoubtedly interferes with the establishment of young scale insects. The spraying should be done when the bark is dry. It must be very thorough, and, in places where the scales have formed incrustations, it is quite difficult to kill all the insects even with this substance. The best method in a large orchard is to spray at two different times, working always on the windward of the trees and spraying the second half when the wind is from the opposite direction to that from which it was when the first half was sprayed. A 10 foot brass extension with two to four cyclone nozzles is almost necessary for the best results. W. H. Hart, of Poughkeepsie, prefers to have the nozzles connected with the extension by a small piece of pipe bent at an angle of about 45° from the line of the extension. Some prefer the nozzles set at a right angle to the extension. It is better to have them turned somewhat, and the precise angle is apt to vary with individual preferences. Trees sprayed with crude petroleum or kerosene should not be trimmed previous to the application as the cuts afford an opportunity for the oil to enter and kill the twig for a short distance. Experiments with this mechanical emulsion on the allied species of Aspidiotus are advised.

Crude petroleum undiluted. Experiments with this undiluted crude oil showed it to be very injurious to plant life, killing two out of four trees and seriously injuring the others. The effects of an application of this undiluted crude petroleum to plumtrees is strikingly shown on plate 8. The lombard plumtree 93 was sprayed with this substance April 11. Compare its appearance on July 2 with that of tree 8, one of the same variety, which was sprayed April 11 with a 20% mechanical kerosene emulsion. A little later in the season tree 93 died. Plate 9 shows the effect of crude petroleum on seckel peartree 101. Note the dead limbs and contrast this with the illustration of the Kieffer peartree 110, which was sprayed on the same date as the others but with Good's whale oil soap no. 3. It is a pleasure to record that this latter tree fulfilled the promise of its bloom. The photograph taken at Kinderhook May 21 of a King appletree, which was painted with crude petroleum Dec. 1, 1899, apparently shows that this substance is more deadly if the application be made in early winter. This tree died during the summer. At present the use of the undiluted article can not be recommended as safe in New York state. Dr Smith states in a recent bulletin that he has found that crude petroleum which ran above 43° on the Beaumé oil scale did not injure the trees, that below 40° was liable to cause serious injury, while the oil giving a reading of

35° was almost uniformly fatal. A safe petroleum, he states, must be either a green or an amber colored paraffin oil, not an asphaltum oil. There is still need of more experiments along this line and of a clearer understanding of just what is meant by crude oil before the use of undiluted petroleum can be advised in this state.

Kerosene. Spraying trees in early spring with ordinary undiluted kerosene did not result in nearly so thorough work as a 20% crude petroleum emulsion, and it was much more injurious to the trees. Its use can not be advised.

Kerosene emulsion. A mechanical 10% kerosene emulsion is a most excellent summer spray to be applied when the young scale insects are numerous, and it has proved harmless to the trees. H. P. Gould has used a 20% mechanical emulsion in summer without harming the trees to an appreciable extent, but as the lower per cent of oil gives very satisfactory results, there is no necessity of using more. Early June applications would probably prove very effective against appletree and scurfy bark lice. The 20% and 25% mechanical emulsions applied in early spring just before the buds started, failed to kill many scale insects, and its use is not recommended at this time.

Other summer sprays. The ordinary kerosene emulsion may be prepared by taking 1½ pounds of hard soap, 1 gallon of boiling water and 2 gallons of kerosene. Dissolve the soap in the water, add the kerosene and then agitate the mixture vigorously by stirring or by repeatedly passing it through a force pump with a nozzle attached, till an emulsion of creamy consistency is obtained, and oil does not rise to the surface. For summer work against the San José scale this may be diluted with 9 parts of water. 1 pound of whale oil soap dissolved in 5 gallons of water may be used in a similar manner without injury to the trees. The sour milk emulsion, which is simply 2 gallons of kerosene and 1 gallon of sour milk, emulsified and diluted as described above, is preferable for limestone regions or where soft water can not be obtained readily. These summer sprays are of service only in checking the San José scale, if previous applications have for some reason proven unsatisfactory. They are very efficient when used against appletree and scurfy bark lice.

Fumigation in orchards. Treatment of pernicious, or San José scale with hydrocyanic acid gas gave most excellent results on small trees in an orchard. Unfortunately it involves the use of costly tents, specially for large trees. It is admirably adapted for large orchards of

small trees, and, where such are reasonably distant from other infested trees, an attempt might be made to exterminate the pernicious scale by fumigation. A box tent 6x6 and 8 feet high, with a hood 7 feet high and a sod cloth some 6 inches wide, was made of 8 ounce duck which was thoroughly painted with boiled linseed oil. Rings for guy ropes were provided at the upper corners, and the tent was lifted by a rope attached to the extremity of the hood. The form of the tent was kept rather constant by using a light frame composed of four side pieces and slender posts at each corner (*see* pl. 10). The tent was handled with the aid of a 35 foot mast and an 8 foot gaff and tackling, and was raised bodily and dropped over the tree. The mast could be fixed to a heavy wagon when used on level ground where the trees are some distance apart. This tent and outfit cost $38, but. as only one was made, much better terms could be secured if several were ordered. The cost of treatment, aside from apparatus, is comparatively little. The secret of doing this work economically consists in having enough tents, so that the men will not have to wait but will be kept busy changing one after another. A little experience will enable those handling the tent to raise it from one tree, swing it over another, lower it, fix it in position, place the chemicals and have the fumigation started within a short time. Five to 10 or more tents could be used in a large orchard to advantage. The economical use of a small number of tents would necessitate some employment near at hand to occupy spare minutes. Dormant trees can be fumigated in this latitude, even when the sun shines, without any apparent injury to the trees. The gas should be allowed to act for 35 minutes or a little longer, and 1 ounce of potassium cyanid (98% pure) to each 75 cubic feet of space, with an equal amount by liquid measure of the best grade of commercial sulfuric acid (specific gravity 1.83) and thrice that amount of water, did not appear to injure the trees in the least, while every scale insect was apparently killed. The above amounts for 100 cubic feet of space gave equally good results. A better proportion, according to Prof. Johnson, is 1 ounce cyanid, 1½ ounces acid and 2¼ ounces water. The cyanid and acid are both very dangerous substances, and should be handled with the greatest care. The cyanid should be conspicuously labeled, kept in a tight, covered can and not taken therefrom till it is to be used. The sulfuric acid is capable of producing horrible burns, and it should be guarded most carefully. The acid should be turned into the water slowly, the mixture being constantly stirred. A glazed earthenware crock is one of the best vessels for the chemicals, and it should be placed under the tent near its middle but not close to the trunk of the tree.

Sometimes the acid spatters a little during the reaction, and this precaution is to prevent injury either to the tree or to the tent. If the tent is already over the tree, look to see that it is properly secured and all of the sod cloth covered, except on the windward side where the chemicals are to be inserted. Then take the cyanid, previously weighed out and placed in a thin paper bag, reach under the tent, carefully drop it into the acid and water and at once draw down the side of the tent and cover the remainder of the sod cloth. The contents of the earthenware vessel, after the tent has been removed, should be carefully buried near the tree. Take special pains to see that none of it comes in contact with a tent. Some preliminary figuring and a little experience will soon make one quite expert in estimating the contents of a box tent above described. Other forms of tents are in use, but the above is probably the best for young trees, though it can not be handled well in a stiff breeze. A bell-shaped tent with its lower edge attached to a large hoop is used considerably in California, and this can be handled in treating small trees without the aid of a mast. The sheet tent, which is nothing more than a square of properly treated canvas of sufficient size, is also much used in that state, specially on large trees.

Fumigation of nursery stock. The mere possibility of the introduction of the San José scale or some other insect pest should be a sufficient reason for the careful fruit-grower to prefer fumigated stock, and the advisability of this treatment in the case of trees open to the slightest suspicion of harboring such an insect is conceded by every careful fruit-grower and nurseryman. The methods of doing this are essentially the same as those mentioned above for orchard fumigation except that it is much more convenient to treat nursery stock in a special building or room, and allowance must be made for the more tender varieties. The essentials of a fumigating chamber are that it must be gas-tight, easily closed and opened from the outside, readily ventilated and so arranged that there will be no difficulty in placing the chemicals where a practically uniform distribution of the gas will be insured. A slat floor, eight or more inches from the ground, under which the gas may be generated, is a decided advantage as it gives a more uniform distribution of the insecticide. The room may be only a few feet square or large enough to contain a load of trees on a wagon, according to the needs of the firm or individual. Small lots of trees can be fumigated in a box, but as a rule this is not advisable. The materials necessary to make a gas-tight house, as worked out by

Prof. W. G. Johnson in Maryland, are substantially as follows: A good frame, covered outside with 1¼x12 inch Virginia pine boards and 1½x4 inch batting. The interior, including the floor, was lined with two-ply cyclone paper, over which four inch flooring was laid. The doors should be made double, refrigerator style, hung with heavy hinges and with bolts at top and bottom and a lock in the middle. There should be a second opening either on the side or roof so as to permit ready ventilation. Trees fumigated in a freight car are very liable to serious injury, and it should not be attempted. A second fumigation should be avoided as the trees may be much damaged. A small room about 4x5x7 is exceedingly convenient, even when there is a large one, as it economizes chemicals in the fumigation of small lots of trees.

The cubic contents of a room should be carefully calculated and the necessary chemicals measured out. Ordinary dormant nursery stock will stand 1½ ounces (avoirdupois) of potassium cyanid (98% pure) to 100 cubic feet of space, according to Mr Sirrine, while for immature stock, bud sticks, etc. but ⅝ ounce should be used. Prof. Sirrine recommends the following proportion: 1⅛ ounces cyanid, 1⅜–1½ fluid ounces sulfuric acid and 4½ fluid ounces water for matured stock, and ⅝ ounce cyanid, ¾ fluid ounce acid and 2½ fluid ounces water for immature stock. Allow the gas to act from 40 to 60 minutes. I have obtained very satisfactory results with the formula given under orchard fumigation; but this latter is undoubtedly good and possibly more economical. Trees in leaf or those with buds started can not be fumigated with safety. The cost of fumigating nursery stock is very slight. One man constructed a house large enough to accommodate 8000 trees of first class size at an expense not to exceed $30. A person with considerable experience in this line finds that trees can be fumigated in quantity at less than ¼c apiece.

Great care should be exercised in this work as well as when treating orchard trees. Special pains should be taken to air the fumigating room thoroughly before allowing any person to enter. The doors should be open at least 10 minutes. This gas is very deadly, nearly odorless and too much care can not be exercised.

TECHNICAL STUDY OF FOUR SPECIES OF ASPIDIOTUS

BY MARGARET FURSMAN BOYNTON

PREFACE

The four species of Aspidiotus, A. ancylus, A. forbesi, A. ostreaeformis and A. perniciosus, are those most commonly found on fruit trees in New York state. They are closely related, and all pass the winter as immature individuals. Much of the inspection of nursery stock is done either in the fall or in the early spring, and it frequently happens that we are called on to identify a species from immature specimens. It is very true that adults should be somewhere in the vicinity of the young, but, as a matter of fact, it is frequently difficult to obtain a satisfactory amount of adult material for study; consequently it is quite important that we be able to separate these species by characters found in immature as well as adult specimens. A study of these species, with directions to give special attention to the immature stages, was assigned to my second assistant, Miss Boynton. The results are given in the following paper.

E. P. Felt

Explanation of terms. In the study of scale insects the final appeal for the determination of species is, of course, to the microscopic detail of the anal plate, made up of the terminal segments, of the adult female. Here peculiar organs appear which are designated by distinctive names, and must be recognized by the terms so used in order to understand any technical description of species. It may be well to illustrate with a diagram (pl. 11) and to explain those which occur in the following characterizations, specially as the usage of these terms varies somewhat with different writers.

The margin of the anal plate is irregular, usually showing broad and somewhat thickened prolongations of the body wall. These are called lobes (pl. 11, fig. 1*a*). In the following species there are two or four, paired bilaterally, as are most of the important organs on this segment, and some times there are the rudiments of a third pair. It is supposed that they are used in shifting the position of the insect under the scale. Spines and plates also ornament the margin. The spines appear under the microscope like short, stiff hairs with bulbous bases. They are likely to extend more or less nearly at right angles to the general line of the margin, are similarly arranged on the two sides of the median line, and are usually on the two surfaces, the dorsal and the ventral. That is, when the focus is fixed

on the spine of one surface, a spine of the other surface may usually be detected close by, though somewhat out of focus (pl. 11, fig. 1 *b*, *b*). This fact will be taken for granted in the following description, and no farther mention of it will be made.

The plates, which are called also gland hairs, or, by Green, squames, extend, in general, nearly parallel to the main axis of the body, and appear soft and for the most part clearer and broader than the spines, and lack the bulbous base, but they assume various forms and may be either simple and hair-like, or forked or fringed at the tip. Varying outlines are shown in figure 1 at *c*, *c*, *c*, *c*. They are often hard to detect definitely, as they are transparent and sometimes disappear in clearing, either through actual dissolution or by attaining the same refractive index as the mounting medium. Their function is probably connected with the excretion of the scale.

The margin is often cut in or incised. In the following species two pairs of incisions can usually be detected, the second being comparatively inconspicuous (pl. 11, fig. 1 *d*, *d'*).

Beside the incisions are heavily chitinized places which appear dark in the cleared specimens. These have been spoken of by Prof. Comstock as the "thickened margin of the incisions," but by later writers are more frequently termed "chitinous processes"; and this phrase I shall use, applying it also to the thickenings which sometimes appear on the inner margins of the median lobes. These last have been spoken of as "club-shaped processes"; but, as this term has also been applied to other organs, it seems wiser to discard it, simply giving definiteness to the term "chitinous processes" by some phrase of location. Different forms of these processes are shown in plate 11, figure 1 *e*, *e*, *e*, *e*. A general thickening of the body wall inward from the lobes frequently occurs, but is usually rather indefinite in appearance (fig. 1*f*).

As the insect is so much flattened, there are practically but two aspects, the dorsal and the ventral. In a well cleared specimen the organs of both sides are visible at once, yet by careful focusing can be distinguished. In plate 11, figure 1, the superficial organs of the ventral side are represented in the left half of the figure; those of the dorsal side on the right. Perhaps the most important of these superficial organs are those which appear on the ventral side of the body as groups of distinct circular organs with several tiny perforations in the middle of each. They are the openings of glands which presumably secrete the covering of the eggs, and have been variously named the spinnerets, the paragenital glands, the circumgenital glands and the ventral grouped glands. I shall

speak of them simply as the ventral glands. They appear only in the adult female and not in all species. They are of rather special interest in economic study because their presence at once proves the specimen to be something other than the pernicious or San José scale, though their absence does not necessarily indicate the contrary. Once seen they are easily recognized, for no other organ resembles them in their definite circular outline and in the manner of grouping (pl. 11, fig. 1 *g*, *g*). In the genus Aspidiotus there are usually four or five groups when present at all. The groups are then spoken of as the anterior or cephalo-laterals, and the posterior, or caudo-laterals, while the fifth group when present is anterior and median and is called by the one or the other of these terms.

In the region of the lateral ventral glands the body wall is thickened (pl. 11, fig. 1*h*). These are the ventral chitinous thickenings, and are to a certain degree characteristic. In A. ancylus and A. ostreaeformis they are somewhat indefinite and appear as if folded or crumpled, in A. forbesi they are nearly straight, narrow and definite, being spoken of in the original description as "club-shaped organs about which the spinnerets are grouped." In A. perniciosus also they are more definite than in A. ancylus and A. ostreaeformis, though not so straight nor so narrow as in A. forbesi, and they appear distinct and dark in the adult female even when the eggs or young are not present to prove the species. This distinguishes the adult but not yet gravid A. perniciosus from the immature specimens of the four species, because in the first and second stages of all four these thickenings, though indicated, are small and indefinite, practically *parenthesis-shaped* and quite different from the third stage appearance. Reference to the figures will make these statements perfectly clear, I think.

The vagina may sometimes be detected as a tranverse opening about the middle of the plate on the ventral side (pl. 11, fig. 1*j*). It does not in general serve in classification, and I have not figured it under the different species.

The dorsal aspect is marked near the base of the segment in the following species by four, transverse chitinous thickenings, two lateral and two median (pl. 11, fig. 1 *k*, *k*). Occasionally there are two fainter longitudinal markings of chitin parallel and near the middle of the segment.

There are also on the dorsal aspect oval openings of more or less prominence in different species, which are perhaps most simply designated the dorsal pores. I have shown different appearances of these seen in focusing in plate 11, figure 1 *l*, *l*. In some species they are numerous and

prominent, in others not nearly so much so. They are perhaps openings of glands which assist in the formation of the scale. Among these are seen curious organs which may seem to be on the surface of the body but are proved by focusing to occur within it in connection with external openings. These have been denominated by Prof. Comstock the wax ducts. In the explanatory figure a few are represented at *m*, *m*, but not in later figures, as they have not been shown to have definiteness of arrangement or classificatory value.

The large circular opening on the dorsal side is the anus (pl. 11, fig. 1*n*). Like the other dorsal organs it is visible from the ventral side also, appearing as a clear area.

I think no other organs of importance are present in the four species here mentioned. There are sometimes visible a few minute round pores and some small superficial spines, or hairs, but they may be disregarded.

Distinguishing species. It is of course a commonplace in many divisions of science, but perhaps in none more than in the study of the Coccidae, that familiarity with forms is necessary for any great degree of certainty in determining species. Descriptions of two or three different species read marvelously alike, and even figures are not absolutely distinctive, because of the great variability in species. Moreover, the untrained eye does not quickly recognize differences, specially where distinctions must be largely comparative. Hence any key to species must in the nature of things be unsatisfactory, for it must be relative in its terms and so can not be used with large degree of certainty in each step till familiarity with the species renders it unnecessary. However, it is sometimes an aid in earlier studies through its emphasis of the more distinctive features, and the following is submitted with that end in view. It applies only to the four species here farther characterized, and perhaps may not exclude other species, which have not fallen under my ken, so that it will be useful only when the student finds it probable that he has one of these four, but is not sure which one. They are the four species of Aspidiotus most frequently brought to the attention of horticulturists in this state, a fact which may justify this limitation of my study.

This key will apply, I think, to the second stages as well as to the mature females, though with hardly as much positiveness. I have been unable to detect constant specific differences in forms before the first molt. Sometimes the question may arise as to whether the form presented is adult or not. This occurs when neither ventral glands nor eggs nor young are present. In this case if the ventral thickenings are

definite and well marked and of considerable size, the specimen is a third stage, female A. perniciosus, though not yet gravid. The second stage of these four species shows only the vague, somewhat parenthesis-shaped thickenings mentioned above and seen in the second stage illustrations. Of course the third stage of the other three species is marked by the ventral glands even before the young appear within the body. In addition, the occasional difficulty in detecting the arrangement of the plates must always be remembered.

Key

A Incisions wide and not very deep. Second pair of lobes small when present. Median lobes rather broad.

B With fringing plates. Second pair of lobes rudimentary or wanting. ..... A. ancylus

BB Plates inconspicuous or wanting. Second pair of lobes usually distinct, though small ..... A. ostreaeformis

AA Incisions narrow. Lobes distinctly two pairs, of good size. Median lobes rather narrow.

B Lobes nearly parallel. Fringing plates. Thickenings on either side of the first incision subequal. No ventral glands even in gravid female ..... A. perniciosus

BB Lobes usually strongly approximating at tips. Plates inconspicuous or wanting. Thickenings on either side of first incisions distinctly unequal. Ventral glands present in adult. A. forbesi

Aspidiotus forbesi *Johns*

PLATES 12 AND 13, FIGURES 1

This species appears to approach A. perniciosus most closely in general outline. (Compare each figure with the second figure of the same plate, A. perniciosus.) It has four distinct lobes: the median ones are notched on the outer margins and approximate at the tips, the second ones are about half the size of the first and usually notched on the outer margin. They also slant slightly inward, giving the species in general a decidedly pigeon-toed appearance. The lobes are close together, because the incisions (two pairs) are narrow. The first incisions are quite deep. The second are not so much so. Prof. Johnson in the original description and figure located four spines on each side of the median line; these are quite prominent. There is a fifth pair often visible near the union of the terminal and the penultimate segments. In general the spines do not

differ from the allied species. The plates when present are few and small; occasionally one or two may be detected between or beside the lobes.

The chitinous processes are very characteristic, though hard to describe. The tips of the lobes are quite heavily chitinized, and the processes extending cephalad along the inner margins of the median lobes are usually comparatively large and distinct. Newell, in his Iowa bulletin no. 43, p. 161, speaks of these as sharp pointed and curved in contradistinction to the almost straight ones of A. ancylus. This difference, if constant, takes very careful focusing to determine, and is not striking, as is proven by the fact that other illustrators of the species have not brought it out. Indeed, the original figure represents these processes as straight and quite different in shape from Newell's figure. This point is probably good additional evidence of the identity of the species when it can be definitely ascertained, but is not the most obvious and easiest criterion. There is also an extension of chitin cephalad near the outer margin of the median lobes.

The chitinous processes on the inner margin of the first incision are large, much larger than those opposite. They are almost pear-shaped with a compound curve on the side toward the median line. That is, they are often abruptly narrowed toward the tip and outer margin of the lobe with a full curve to the very broad and plump cephalic part. This may seem a hazy description till somewhat cleared by study of the figures and by familiarity with the forms. As a matter of fact these chitinous processes are quite distinctive in A. forbesi being easily distinguished from the more indefinite and irregular ones of A. ostreaeformis and A. ancylus and somewhat less certainly from A. perniciosus by the narrower distal part, and specially by the usually marked superiority in size to the opposite process, while in A. perniciosus the two processes are subequal. The chitinous processes about the small second incision vary more than in the case of the first incision.

The adult female shows ventral glands in 5 groups. Johnson gives 1–3 for the anterior group, 3–7 for the anterior laterals and 3–5 for the posterior laterals. The general arrangement of these is somewhat linear.

The ventral chitinous thickenings within the posterior lateral groups are nearly straight and club-shaped and are usually narrow and definite, as stated above. Sometimes a fainter, less heavily chitinized fold or fork appears, but the main and obvious process is more or less nearly as illustrated and is usually in line with a small, straight, more heavily chitinized portion of the general thickening inward from the base of the lobes mentioned in the paragraph for the explanation of terms.

On the dorsal side the anus is easily detected. The dorsal pores are small and clean-cut and usually run in two rows, on either side of the median line, one from the second incision toward the lateral transverse chitinous thickening and the second row laterad of that and running clear to the outer end of the same thickening, one pore usually being against the thickening. The number of these pores is variable but I have several times counted six or eight in each row. At the first incision there are two or three pores.

The second stage of A. forbesi (pl. 13, fig. 1) resembles the third in general, though, of course, it is smaller in size. At this stage, the second lobes seem somewhat smaller comparatively and are more often rounded than notched. The characteristic approximation at the tips usually occurs, and aids in distinguishing this form from the second stage of A. perniciosus which usually shows nearly parallel lobes. The chitinous processes are usually of the characteristic shape, but sometimes are not so marked in disparity of size as in the adult. The spines and plates are as in the adult. The ventral glands are of course wanting, and the ventral thickenings are faint and indefinite, as in the others of these four species. The dorsal pores are fewer than in the adult but represent in scattering lines the arrangement of the later stage. Quite often one may be observed even beyond the lateral chitinous thickenings.

Aspidiotus perniciosus *Comst.*

PLATES 12 AND 13, FIGURES 2

The adult female of the pernicious or San José scale shows two distinct pairs of lobes, which, while approximating somewhat at the tip, do not usually come so close together as in A. forbesi. The median lobes are rather long and narrow in appearance, are deeply notched on the outer margin and often on the inner margin nearer the tip than is the outer notch. The second lobes are distinct, well marked, about half the size of the first, rounded at the tips and notched on the outer margin. The spines are as in allied species, one on each lobe, one beyond the second incision and the fourth about halfway from the lobes to the penultimate segment. The plates are quite numerous and easily distinguishable, giving a somewhat fringed appearance that helps to differentiate this species from A. forbesi. There are usually two inconspicuous plates between the median lobes, and two or three long and slender ones at the first incision, three or two often somewhat serrate ones at the second incision and three broad, often two-pointed ones, between the third and

fourth spines. My figure shows that considerable variation occurs even in a single specimen. There are two pairs of incisions, the first between the first and second lobes and the second outside the latter lobe. The first incisions are usually very deep, while both pairs are narrow.

The ends of the lobes are heavily chitinized. The chitinous processes extending along the mesal margins of the median lobes I have not found large and definite so frequently as in A. forbesi. Those on the inner margin of the first incision are of the general type of the latter species and are strongly curved toward the lobe, but are more usually broader at the base of the process, that is, toward the tip and outer edge of the lobe. This is not, however, a very positive difference. The opposite processes nearly equal these in size, which is not the case in A. forbesi. Sometimes I have not distinguished the process of the outer edge of the second incision, but it is often present of about the same size as that of the inner edge.

Ventral glands are wanting even in the adult. The chitinous thickenings of this region are present however as definite and narrow dark areas in well cleared specimens. They are twice bent and of the shape shown in the figure. These will serve to differentiate the adult A. perniciosus from the immature forms of any of these species, even though eggs and young are not present to certify to the maturity of the form.

The anus is of medium size, and is about as far from the ends of the chitinous processes as these are from the tips of the lobes.

The transverse chitinous processes are frequently broad and somewhat irregular. They are not so usually prominent and definite as in A. ostreaeformis. The dorsal pores are comparatively few, small and inconspicuous. They are usually present in traces of three short lines; the first runs from the second incision; the second just laterad of this and the third, consisting of only a few scattering pores, is still farther laterad. Quite frequently a single pore is to be seen anterior to the lateral transverse thickening.

The second stage (pl. 12, fig. 2) is much the same in general arrangement and in the outline of parts except that the ventral chitinous thickenings are parenthesis-shaped and lack definiteness, the dorsal pores are fewer and more scattering, and the plates are not always so easily detected. It may be most easily confounded in this stage with A. forbesi, but it usually displays plates enough in carefully prepared specimens to separate it from that form, and will show also, on greater familiarity, the same difference in relative size of the chitinous processes and in relative position of the lobes which is to be marked in the adult forms.

Aspidiotus ancylus *Putnam*

PLATE 11, FIGURE 2 AND PLATE 15, FIGURE 1

This species possesses in general but a single pair of lobes, the median ones, which vary considerably in length and outline, but in a fresh adult female they are usually quite long and nearly straight on the inner and outer margins, with the tips rounded and notched on the outer edge, and often also on the inner edge near the tip. Reference to the figures will explain this statement When worn by long and rough use, the lobes may be much shorter and worn to an oblique curve instead of the form above described. They sometimes approximate slightly at the tips. Occasionally rudiments of other lobes can be made out.

Spines are as usual. Plates are quite numerous fringing the segment; two or three occur at each incision. Comstock speaks of them as usually simple, but they are at least frequently toothed in the mounts I have examined. There are three to four or five irregular and usually simple and slender plates between the third and fourth pairs of spines. The incisions are wide and not deep.

The chitinous processes at the incisions are variable, being often quite large. The one on the inner margin of the first incision is frequently much larger than the opposite one, but they may be subequal. They are of the straighter type, resembling A. ostreaeformis in this rather than A. perniciosus and A. forbesi. The median ones are usually quite large and prominent, but straight.

The ventral glands are in four or five groups: the anterior ones are 0–6, the anterior laterals 6–14, the posterior laterals, 5–8. These numbers are on Comstock's authority. The glands show usually a somewhat linear or scattering arrangement not the compact circular appearance of typical A. ostreaeformis. The ventral thickenings are usually vague and irregular. The anus does not differ strikingly from A. ostreaeformis.

The dorsal pores present quite a range of variation. Dr Marlatt informs me that they are typically much fewer than in A ostreaeformis or A. juglans-regiae. The office collection shows many specimens, however, where they are abundant, appearing usually in three or even four well defined rows. On each side of the median line one row extends from the second incision toward the lateral transverse thickening, another laterad of this extends clear to the outer margin of the same thickening and there is still another, though shorter one, outside of this, while a group of three or a line of four or five appears at the first incision.

Where the pores are fewer the two lines first mentioned can usually be distinguished, but are less crowded than in the extreme form, while the third row is represented by two or three scattering pores or not at all, and the pores at the first incision are two or three in a group close to the ends of the chitinous processes.

The second stage of A. ancylus seems not always definitively different from the same stage of A. ostreaeformis. I have seen in mounts from undoubted A. ancylus material one or two second stage specimens, which had the small, narrow yet distinct second lobes together with absence of the plates that characterize A. ostreaeformis. Similarly, I have seen in A. ostreaeformis mounts second stage specimens that suggest A. ancylus. Of course, it is always possible that the two species are breeding side by side and may be taken at the same time in the younger forms, even if they have not been so taken in the adult stage. It seems to me that, in distinction between the two species, if fringing plates are present, whether or not rudimentary lobes appear, it is pretty surely *not* A. ostreaeformis but is presumably A. ancylus. If plates are not discernible, and a second pair of lobes appears, it is pretty safely the former species. But, where there are neither plates nor second lobes to be discovered, additional evidence should be sought. In any case an identification from second stage material may safely be modified with "probably."

Aspidiotus ostreaeformis *Curtis*

PLATE 14 AND PLATE 15, FIGURE 2

A. ostreaeformis is one of the large species, the adult female often attaining a diameter of $1\frac{1}{2}$ mm according to Dr Marlatt. He gives an extended description and a beautiful figure on page 81 of the *Proceedings of the 11th annual meeting of the association of economic entomologists* (U. S. dep't agric. div. ent. Bul. 20, n. s.).

The median lobes of this species vary somewhat in shape, but are in general broad with a distinct though shallow notch on the outer margin. The second pair are much smaller but usually easy to distinguish and quite characteristic in shape. They are at least often considerably narrower in proportion than in the specimen represented in my figure. Both pairs are usually heavily chitinized, and sometimes a rudimentary third pair seems to be indicated by the arrangement of chitin beyond the second incision.

The spines are as in allied species; the plates are inconspicuous, but two short stout ones are usually to be discerned at each incision.

The chitinous processes are subequal on the two sides of each incision. They are quite large beside the first incision but are somewhat irregular in shape and usually not so strongly curved on the inner side as is the case in A. perniciosus, and those on the inner edges of the median lobes are variable, sometimes easily detected and in other cases vague and indefinite.

The ventral glands in the adult female are quite numerous and are usually in compact, nearly circular groups, while those of A. ancylus are more likely to be linearly arranged. Dr Marlatt gives the numbers as averaging six for the anterior group, which is usually much the smaller, and 10 or 12 for each of the lateral groups, but the numbers vary quite considerably.

The thickenings in the region of the ventral glands are indefinite and look somewhat like crumplings or foldings of the body wall.

The anus is small and quite distant from the median lobes. The margins, however, run up to embrace it.

Dr Marlatt says:

The dorsal pores are quite characteristic. There are usually two between the first pair of processes and a row of five or six extending from the second pair of processes and after a considerable interval, continued near the lower group of paragenital glands in one or two additional pores. A lateral row of about 10 or 11 pores extends from near the base of the first pair of spines to the lateral chitinous thickenings. Differing from most of its near allies, it has a group of six or seven pores near the basal angles of this segment.

In the next to the last sentence "first pair of spines" means the first spines beyond those associated with lobes, as I think will be seen on study of this figure. The number of these pores varies somewhat, yet there is a certain characteristic general appearance in this arrangement that becomes familiar and at sight suggests A. ostreaeformis to a student of these forms. I have often found three pores in a group at the first incision, and sometimes there are many more in each of the groups than the numbers given above. I have found two lots on willow in our collection where the number and closeness of arrangement of these pores suggest A. juglans-regiae, so that Dr Marlatt, to whom the specimens were submitted, advances interbreeding as a possible explanation of the phenomena. The lobes are three on each side of the median line in this willow form, and the ventral glands are more numerous than in typical A. ostreaeformis, while the specimens are larger in size.

In the second stage the two pairs of lobes are usually distinctly present, though the second are minute. Sometimes a hint of the rudimentary third ones can be discerned. The incisions are wide and not

deep. The plates and spines are as in the adult; the chitinous processes are subequal and similar to those in the adult though of course smaller; the ventral glands wanting, ventral thickenings parenthesis-shaped; anus and transverse thickenings as in the adult. The dorsal pores are fewer than in the adult but are plainly of the same general arrangement, with two or three at the first incision, a row from the second incision consisting usually of three pores and the lateral row with about six running up to the lateral transverse thickening. There are usually one or two pores still laterad of this and generally two or more to represent the basal angle group. This is closely similar to the second stage of A. ancylus, but may be distinguished in carefully prepared specimens by the absence of the fringing plates which characterize the latter. Usually the difference in the general shape of the lobes and the deeper, narrower incisions of A. perniciosus and A. forbesi will distinguish the second stages of these two species from those of A. ostreaeformis to one at all familiar with these forms.

SCALE INSECTS, COCCIDAE, IN NEW YORK STATE

This list of 78 species gives some idea of the number of scale insects farmers, horticulturists, nurserymen and those interested in greenhouses have to contend with. It also has value in that it indicates about what forms may be found on certain plants in the state, though the list of food plants of a number of species could undoubtedly be considerably increased by farther collecting. Those occurring on any one plant can easily be ascertained by referring to the index, where the species are listed under the names of the plants on which they may be found. Many of these scale insects are not injurious, but there are also a number of pests of considerable importance. This list is largely based on previous records, and many additions would undoubtedly result from special collecting. An effort has been made to exclude unreliable records. Some of the earlier determinations on which records depend may be erroneous, but it is almost impossible to eliminate this source of error.

It is a pleasure to acknowledge the assistance of several coworkers in the preparation of this list. Messrs Comstock, Howard, King, Lowe, Parrott, Pettit and Slingerland have very kindly called my attention to overlooked records, given suggestions as to the synonymy, and also placed at my disposal their own unpublished notes.

Coccinae

Eriococcus azaleae Comst., on azalea in a greenhouse, Geneva. Comstock, 2d Cornell rep't. p. 132; on wild azalea (Azalea nudiflora), Coy glen, Ithaca. Insect life. 3:52.

Gossyparia ulmi Geoff., elm bark louse, on English, Scotch, Camperdown, American and slippery elm. It is known to occur at the following places: Albany, Catskill, Delmar, Flushing, Ghent, Marlboro, Ogdensburg and Rochester. *See* rep'ts N.Y. state ent. Also Chatham and Loudonville. Howard in letter.

Ripersia maritima Ckll., on roots of Spartina, Hempstead Harbor. Cockerell, Insect life. 7:42.

Dactylopius citri Risso, in greenhouses, New York. Howard in letter.

Dactylopius longispinus Targ. (D. adonidum in error) common "mealy bug." This insect is probably present in most greenhouses in the state.

Dactylopius trifolii Forbes, on red clover, Ithaca. R. H. Pettit in letter.

Dactylopius sp. on quince. Lowe, Geneva Bul. 180. p. 128.

Dactylopius sp. (D. ?cockerelli) on grass roots beneath a flat stone and attended by Lasius flavus, Geneva, May 30, 1901. Parrott in letter.

Phenacoccus aceris Sign. (syn. Pseudococcus aceris Geoff.), on maple leaves, Athens. N. Y. state ent. Rep't. 15:616. At Brooklyn and Middletown on maple. Howard in letter.

Asterolecaniinae

Asterolecanium variolosum Ratz. (syn. A. quercicola Auctt.) oak scale insect on English oak, Newburgh. N. Y. state ent. Rep't. 10:519. Geneva and Cortland. ——— 15:617. On oak, Cortland and golden oak at New York. Howard in letter. At Rochester. Slingerland in letter.

Ortheziinae

Orthezia americana Walk., on burdock, Ithaca. Comstock, Agric. rep't. 1880. p. 349.

Orthezia insignis Doug., greenhouse Orthezia, probably a very common greenhouse pest, on coleus, Rye and Ithaca, Lounsbury, Mass. Agric. coll. Rep't. 1895. p. 112–13.

Lecaniinae

Kermes galliformis Riley, oak Kermes, on oak, Middletown. N. Y. state ent. Rep't. 12 : 317. Several species have passed under this name, but the true K. galliformis probably occurs in this state. Oak at Brooklyn. Howard in letter.

Kermes pettiti Ehrh., on oak, Ithaca. King, Psyche. 9 : 81.

Kermes trinotatus Bogue, on oak, Albany. Can. ent. 32 : 205.

Lecanium antennatum Sign., on oak. Signoret, Essai sur les cochenilles. 1873. p. 413; Comstock, 2d Cornell rep't. p. 132.

Lecanium armeniacum Craw, on grape, Erie county. N. Y. state ent. Rep't. 14 : 260; on English gooseberry, Geneva, Brighton. ———15 : 617; on Prunus simoni, Defreestville, state collection.

Lecanium caryae Fitch,[1] on hickory. Fitch rep't. 3 : 125; Comstock, 2d Cornell rep't. p. 133. At Geneva. Lowe, in letter.

Lecanium cerasifex Fitch, on cherry. Fitch rep't. 3 : 50; Comstock, 2d Cornell rep't. p. 133; on maple, oak, Menands, Geneva. N. Y. state ent. Rep't. 14 : 261; on peach, Geneva. ———15 : 617; on apple, Union Springs. ———16 : 1044; on white ash, Stanley, state collection. On plum, Geneva. Lowe in letter.

Lecanium corylifex Fitch, on hazelnut. Fitch rep't. 3 : 155; Comstock, 2d Cornell rep't. p. 133.

Lecanium cynosbati Fitch, on wild gooseberry. Fitch rep't. 3 : 118; Comstock, 2d Cornell rep't. p. 133.

Lecanium fitchii Sign., on raspberry or blackberry. Signoret, Essai sur les cochenilles. 1873. p. 404; Comstock, 2d Cornell rep't. p. 133.

Lecanium fletcheri Ckll. King, Can. ent. 31 : 141. At Ithaca. Pettit in letter.

Lecanium hemisphericum Targ., common in greenhouses. Comstock in letter; at Brighton. Howard in letter.

Lecanium hesperidum Linn., common in greenhouses and on house plants. On sweet bay, fern and lemon, Buffalo, Alden and Nyack. Howard in letter.

Lecanium juglandis Bouché, on butternut. Fitch rep't. 3 : 145 (as L. juglandifex); Comstock, 2d Cornell rep't. (as L. juglandifex Fitch) p. 134; on plum, Rochester, Menands. N. Y. state ent. Rep't. 10 : 518.

Lecanium lintneri Ckll. & Bennett, on sassafras, Lake Mohonk Cockerell, Am. naturalist. 29 : 381.

1 Species described by Dr Fitch or received from him by others are probably New York species and are therefore included in this list.

Lecanium nigrofasciatum Perg., peach Lecanium, on sugar maple, Poughkeepsie, Ithaca. Pergande, U. S. dep't agric. div. ent. Bul. 18, n. s. p. 27. At Brooklyn. Howard in letter. On soft maple, Albany, state collection.

Lecanium persicae Fabr., on peach. Comstock, 2d Cornell rep't. p. 134; at Jamaica. Howard in letter.

[1]Lecanium prunastri Fonsc., New York plum scale insect, on cherry, Ardisia crenulata, Albany, Flushing. N. Y. state ent. Rep't. 14 : 261. A serious enemy of the plum in western New York; many localities have been recorded. *See* Cornell Bul. 83, 108, ——— rep't '95, Geneva Bul. 136.

Lecanium pruinosum Coq., on grapevine, Brighton. N. Y. state ent. Rep't. 15 : 617.

Lecanium quercifex Fitch, on white oak. Fitch rep't. 5 : 25; Comstock, 2d Cornell rep't. p. 135.

Lecanium quercitronis Fitch, on black oak. Fitch rep't. 5 : 25; Comstock, 2d Cornell rep't. p. 135.

Lecanium ribis Fitch, on currant. Fitch rep't. 3 : 109; Comstock, 2d Cornell rep't. p. 135; On Ostrya and Carpinus, Albany. Howard in letter.

Lecanium tulipiferae Cook, tulip tree scale insect, Rochester. N. Y. state ent. Rep't. 10 : 518; on tulip tree, Somers. ———13 : 374; on Magnolia soulangea, Fishkill, at Highland Falls. ——— 14 : 261; ———15 : 617; Mount Vernon. ———16 : 1044; at Watkins and Nyack. Howard in letter. At Poughkeepsie, Slingerland in letter.

Lecanium n. sp. on Pinus rigida, Karner, state collection.

Lecanium n. sp. on maple, Albany. Howard in letter.

Pulvinaria acericola Walsh and Riley, maple leaf Pulvinaria, on maple, Ithaca. Howard. U. S. dep't agric. div. ent. Bul. 22, n. s. p. 17.

Pulvinaria innumerabilis Rathv., cottony maple tree scale insect, on soft maple, sugar maple, elm and grape, numerous localities recorded. *See* rep'ts N. Y. state ent.

Pulvinaria maclurae Kenn. King, Can. ent. 31 : 143. This record is open to question, though this species may occur in the state.

Diaspinae

Aspidiotus abietis Schr., on pitch pine, Ithaca. Comstock, Agric. rep't. 1880. p. 306; (syn. A. pini) on under surface of hemlock

[1]Mr King has found in material sent from New York state as this species L. juglanis Bouché and L. rotundum Sign.

leaves, Ithaca. Comstock, 2d Cornell rep't. p. 57; on pitch pine, Karner, state collection.

Aspidiotus aurantii Mask., in greenhouses, New York Howard in letter.

Aspidiotus ancylus, Putn., Putnam's scale insect. It occurs on many food plants and has been recorded from numerous localities. *See* p. 327.

Aspidiotus betulae Baer, on horse-chestnut, Buffalo, state collection.

Aspidiotus comstocki Johns., on sugar maple, Ithaca. Ill. state lab. nat. hist. Bul. 1896. 4:385.

Aspidiotus forbesi Johns., cherry scale insect, on apple, Manchester. N. Y. state ent. Rep't. 16:1044; on plum, Geneva. Howard in letter; on pear, Geneva, state collection. *See also* p. 331.

Aspidiotus juglans-regiae Comst., English walnut scale insect, on locust, pear and cherry, New York state. Comstock, 2d Cornell rep't. p. 61. Probably on maple, Albany, state collection. On willow, Fredonia. Slingerland in letter. At Brighton. Howard in letter.

Aspidiotus hederae Vall. (syn. A. nerii Bouché), white scale insect of ivy, common in greenhouses. *See* p. 334.

Aspidiotus lataniae Sign. (syn. A. cydoniae Comst.), on palm in greenhouse, Cobleskill. On Areca lutescens, Kentia fosteriana, Albany, state collection.

Aspidiotus ostreaeformis Curtis, European fruit scale insect, occurs in many localities. *See* notice on p. 325.

Aspidiotus perniciosus Comst., pernicious, or San José scale, occurs on many food plants and has a wide distribution. *See* notice on p. 309–11.

Aspidiotus punicae Ckll., Seward. Howard in letter.

Aspidiotus ulmi Johns., on catalpa, Buffalo, on elm, Le Roy, Albany, state collection.

Aspidiotus uvae Comst., possibly in the state, as a specimen without locality label occurs in the state collection.

Pseudaonidia species on Camellia japonica at New York. N. Y. state ent. Rep't. 15:616.

Chrysomphalus aonidum Linn. (syn. C. ficus Ashm.), on palm in greenhouse at Gloversville. Insect life. 7:360; on Ficus ?carica, Strelitzia reginae, Kentia belmoreana, Coe-

logyne cristata, Monstera deliciosa, Phoenix reclivata, P. dactylineata, ivy, Chinese dwarf orange, Albany, state collection.

Chrysomphalus dictyospermi Morg., on ivy, Coelogyne cristata, Kentia belmoreana, K. fosteriana, Areca lutescens, in Albany greenhouses, state collection.

Diaspis calyptroides Costa (syn. D. cacti Comst.), cactus scale insect, on cactus, Ithaca. Comstock, 2d Cornell rep't. p. 91; on Cereus grandiflora, New York, on Epiphyllum truncatum, Albany, state collection.

Diaspis carueli Targ., juniper scale insect, on Irish juniper, Sing Sing. N. Y. state ent. Rep't. 14 : 262.

Diaspis ostreaeformis Sign., imported from France on nursery stock in 1898, but it was probably exterminated; letter from M. V. Slingerland. There is danger of importing this insect in the future, even if it is not established here at present.

Aulacaspis bromeliae Kern. on Corypha australis, Albany greenhouse, state collection.

Aulacaspis boisduvalii Sign., a greenhouse or house species on orchid, Gouverneur. N. Y. state ent. Rep't. 14 : 262. On Seaforthia elegans, Phoenix reclivata, P. dactylineata, P. canariensis, Strelitzia reginae, Livistonia rotundifolia, orchid, variegated pineapple, palms. Albany, state collection.

Aulacaspis rosae Sandb., rose scale, on rose, Brooklyn. N. Y. state ent. Rep't. 7 : 384; on blackberry, Brighton.——16 : 1045; on blackberry, Geneva, Lebanon Springs; on raspberry, Onteora Mts, Greene co., and at Geneva. Howard in letter; At Ithaca, Slingerland in letter. On blackberry, Stanley, on raspberry, Hudson, state collection.

Howardia elegans Leon., in a greenhouse on Cycas revoluta, Altamont. N. Y. state ent. Rep't. 16 : 1045; on Zamia integrifolia and Cycas revoluta, Albany, state collection.

Parlatoria pergandii Comst., orange chaff scale insect, on orange, Sing Sing. N. Y. state ent. Rep't. 14 : 262; on tangerine, New York.——15 : 618. A greenhouse species. Geneva on orange. Howard in letter.

Parlatoria proteus Curtis on Vanda suava in greenhouse at Ithaca. R. H. Pettit in letter.

Parlatoria theae Ckll. (syn. P. viridis Ckll.) on imported Japanese maples. N. Y. state ent. Rep't. 15 : 618. The lot was seized and fumigated. This species was subsequently imported on another lot, which was also treated. It is very probable that this insect has been imported before, and it may prove hardy in our climate.

Mytilaspis citricola Pack., orange scale insect. Occurs on oranges in the markets and probably on orange trees in greenhouses. On lemon at Geneva. Howard in letter.

Mytilaspis gloverii Pack., a greenhouse species. King, Can. ent. 31 : 229.

Mytilaspis pomorum Bouché, the appletree bark louse, a common, widespread species with a large number of food plants. *See* p. 297, 298.

Pinnaspis pandani Comst., palm scale, in greenhouses, New York, state collection.

Chionaspis americana Johns., elm Chionaspis, on elm, Brooklyn. Cooley. Mass. expt. sta. Special bul. 1899. p. 43. At Cohoes, Geneva. Howard in letter. On American elm, Albany, state collection.

Chionaspis euonymi Comst., Euonymus scale insect, on Euonymus, lilac, Prunus pissardi at Fishkill, Greatneck and Irvington. N. Y. state ent. Rep't. 15 : 618; on Celastrus scandens, Blauvelt, state collection. At Brooklyn. Howard in letter. At Tarrytown, Slingerland in letter.

Chionaspis furfura Fitch, scurfy bark louse, a very common species. *See* p. 302–3 for food plants and distribution.

Chionaspis lintneri Comst., Comstock on alder, Viburnum lantanoides. 2d Cornell rep't. p. 103; on Cornus, Rochester, state collection.

Chionaspis pinifoliae Fitch, pine leaf scale insect, on pines, Matteawan. N. Y. state ent. Rep't. 7 : 384; at Albany, Geneva. ——— 15 : 618; at Saratoga, state collection. At Newburgh, Fayetteville. Howard in letter. At West Somerset. Slingerland in letter. A common species with a wide distribution.

Chionaspis salicis-nigrae Walsh, on willow, Ithaca. Comstock, Agric. rep't. 1880 (C. salicis in error) p. 320. On Cornus alternifolia, Kashong glen near Geneva. Parrott in letter.

Hemichionaspis aspidistrae Sign., on fern in greenhouse, Ithaca. R. H. Pettit in letter, on Asplenium viviparum, and sago palm or Cycas revoluta, Albany, state collection.

EXPLANATION OF PLATES

Plates 1–7 were executed from nature, under the author's direction, by L. H. Joutel of New York.

PLATE 1

Appletree bark louse

Mytilaspis pomorum Bouché

FIG.

1 Eggs and two empty, shriveled shells, very much enlarged
2 Active young, very much enlarged
3 Young just after they have settled on the bark, very much enlarged
4 Partly grown scales with an old one, much enlarged
5 Partly grown young still more enlarged
6 Male scale, much enlarged
7 Female scale, much enlarged
8 Female scale reversed, showing shriveled parent and eggs, much enlarged
9 Female scales on poplar bark, natural size
10 Female, very much enlarged

PLATE 2

Scurfy bark louse

Chionaspis furfura Fitch

FIG.

1 Female scale broken open to reveal the purplish eggs within, very much enlarged
2 Active young, very much enlarged
3 Partly grown scales, much enlarged
4 Adult female and two male scales, much enlarged
5 Female scale reversed, showing egg and shrunken body of mother, very much enlarged
6 Male scale, very much enlarged
7 Scales on twig, natural size
8 Male scales on bark, much enlarged
9 Adult female just before oviposition, much enlarged

PLATE 3

Pernicious or San José scale insect

Aspidiotus perniciosus Comstock

FIG.

1 Recently established scale in white stage on green twig, very much enlarged. (Note red coloring around it)
2 Recently established young on green twig natural size. (Note red coloring around scales)
3 Pear showing young scales and the red discoloration, natural size. (Same is shown on the leaf)
4 Young scales in white stage on twig, natural size
5 Mass of old scales, some young black ones and some in white stage on a twig, natural size
6 Group of yellowish adult scales, enlarged
7 Group of dark adult scales surrounded by many young black ones, enlarged
8 Adult male scale, very much enlarged
9 Adult female scale, very much enlarged
10 Adult female, very much enlarged
11 Active young, very much enlarged
12 Perfect male, very much enlarged
13 Young in black stage, very much enlarged

PLATE 4

European fruit scale insect

Aspidiotus ostreaeformis Curtis

FIG.

1 Recently established young, greatly enlarged
2 Young in white stage, natural size
3 Portion of above, much enlarged
4 Half grown scales, much enlarged
5 Half grown scales, somewhat enlarged
6 Piece of badly infested bark, natural size
7 Portion of twig showing mass of scales, much enlarged
8 Male scale, very much enlarged
9 Female scale, very much enlarged
10 Female as removed from under a scale, very much enlarged
11 Active young, very much enlarged

PLATE 5

Putnam's scale insect

Aspidiotus ancylus Putnam

FIG.

1 Group of young scales on pear, enlarged
2 Several young scales, greatly enlarged
3 Portion of currant twig with young scales, natural size
4 Same much enlarged
5 Half-grown scales on white birch, enlarged
6 Badly infested twig of Ilex verticillata, enlarged
7 Portion of above, greatly enlarged
8 Male scale, very much enlarged
9 Female scale, very much enlarged
10 Female as removed from under a scale, very greatly enlarged
11 Young scale insect, very greatly enlarged

PLATE 6

Cherry scale insect

Aspidiotus forbesi Johnson

FIG.

1 Dorsal view of white scale, very much enlarged
2 Same from a nearly side view, very much enlarged
3 Group of young scales, much enlarged
4 One scale from the above, still more enlarged
5 Two half-grown scales, very much enlarged
6 Twig infested with full-grown scales, natural size
7 A group of scales from the above, more enlarged
8 Female scale, very much enlarged
9 Two male scales, very much enlarged
10 Female as removed from under a scale, very much enlarged

PLATE 7

White scale insect of the ivy

Aspidiotus hederae Vallot

FIG.

1 Female as removed from under her scale, very much enlarged
2 Active young, very much enlarged
3 Young scale, very much enlarged
4 Adult female scale, very much enlarged
5 Shriveled female as found under the scale after all her eggs are laid, very much enlarged

FIG.

6 Group of female and half-grown scales, much enlarged

7 Spray of ivy showing scales on upper and under surface of the leaves and on the stem, natural size

8 Yellowish eggs and young found under a scale, very much enlarged

PLATE 8

Effects of undiluted crude petroleum

Tree 93, lombard plum, was sprayed with crude petroleum April 11, and the tree photographed July 2.

Tree 8, one of the same variety, was similarly sprayed with a 20% mechanical emulsion of crude petroleum, and the tree photographed July 2. Compare the two in order to gain an idea of the effect of crude petroleum.

PLATE 9

Effects of undiluted crude petroleum

Tree 101, a seckel pear, was sprayed with undiluted crude petroleum, April 11, and photographed July 2.

The king appletree was painted with crude petroleum Dec. 1, 1899, and photographed May 21. This tree died during the summer, throwing out scarcely a leaf.

Tree 110, a Kieffer pear sprayed with Good's whale oil soap April 11, is represented by way of contrast.

PLATE 10

Fumigating tent in operation. The tent is lifted bodily from the tree with the aid of the tackle and pole. The hood was kept distended in this instance in order to make the cubic contents more constant.

PLATE 11

FIG.

1 Diagrammatic representation of anal plate of adult female scale insect, showing peculiar organs. Those belonging specially to the ventral surface are represented on the left half of the figure; those of the dorsal surface on the right.

a, a lobes, heavily chitinized at tip

b, b, b, b spines, on ventral and on dorsal surfaces, the latter slightly out of focus

c, c, c, c plates, of varying forms

d, d, d, d incisions in margin of anal segment

FIG.

e, e, e, e, e, e, e, e chitinous processes, or thickened margins of incisions

f general thickening inward of body wall

g, g, g ventral grouped glands, or spinnerets

h ventral chitinous thickening

i vagina

k, k transverse chitinous thickenings of dorsal wall

l, l, l, l dorsal pores, showing different appearances seen in focusing

m, m wax ducts, within body

n anus

2 Aspidiotus ancylus Putnam, adult female. Note fringing plates, the single pair of lobes, and the linear arrangement of ventral glands. Compare with A. ostreaeformis, plate 14.

PLATE 12

FIG.

1 Aspidiotus forbesi Johnson, adult female. Note chitinous thickenings and form of lobes. Compare with figure 2.

2 Aspidiotus perniciosus Comstock, adult female. Ventral glands are absent. Note plates.

PLATE 13

FIG.

1 Aspidiotus forbesi Johnson, second stage. Compare with adult, plate 12, figure 1, and with A. perniciosus, second stage, on plate with it.

2 Aspidiotus perniciosus Comstock, second stage. Compare with adult, plate 12, figure 2.

PLATE 14

Aspidiotus ostreaeformis Curtis, adult female. Note form of second lobes and grouping of ventral glands. Compare with A. ancylus, plate 11, figure 2, and with the other species figured.

PLATE 15

FIG.

1. Aspidiotus ancylus Putnam, second stage. Note plates in comparison with A. ostreaeformis at figure 2. Compare also with adult, plate 11, figure 2.

2 Aspidiotus ostreaeformis Curtis, second stage. Compare with adult, plate 14.

L. H. Jeutel, 1900

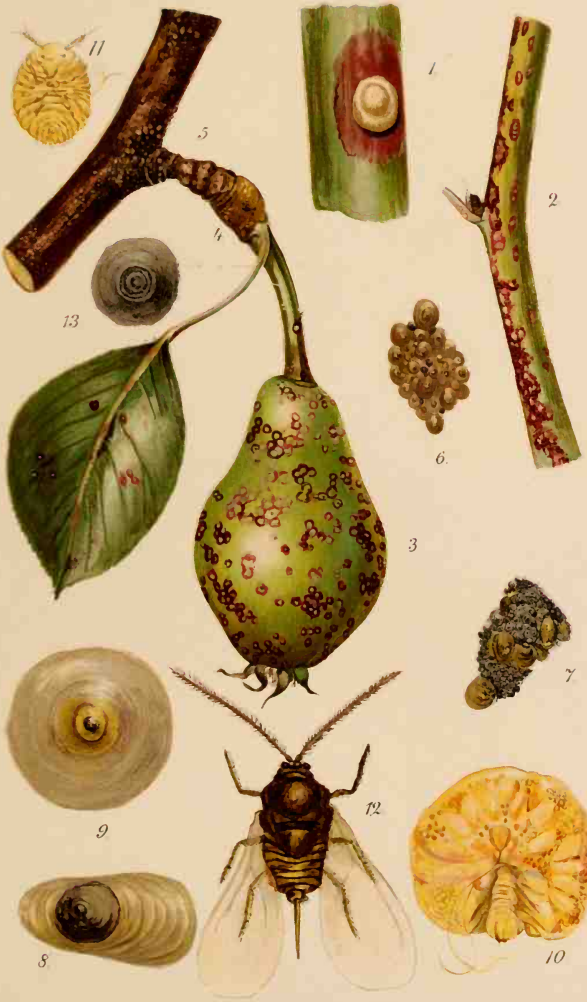
James B. Lyon, State Printer

Appletree bark louse

L. H. Joutel, 1908

James B. Lyon, State Printer

Scurfy bark louse



L. H. Joutel, lith. James B. Lyon, State Printer

Pernicious or San José scale insect

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L. H. Joutel, 1900

James B. Lyon, State Printer

European fruit scale insect

3

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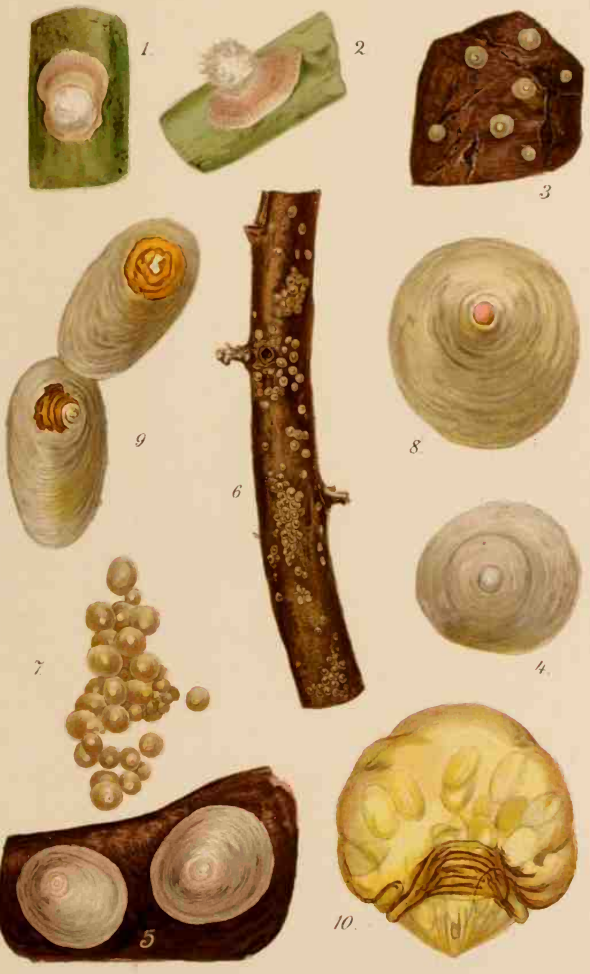
L. H. Joutel, 1908

James B. Lyon, State Printer

Putnam's scale insect



L. H. Joutel, 1900

James B. Lyon, State Printer

Cherry scale insect

L. H. Joutel, 1908 James B. Lyon, State Printer

White scale insect of the ivy

Tree 8 Lombard plum Photo July 2
20% KEROSENE

Tree 93 Lombard plum Photo July 2
CRUDE PETROLEUM

(Compare the two trees)

Tree 101 Seckel pear Photo July 2
CRUDE PETROLEUM

Tree 110 Kieffer pear Photo May 14
WHALE OIL SOAP

Painted Dec. 1 King apple Photo May 21
CRUDE PETROLEUM

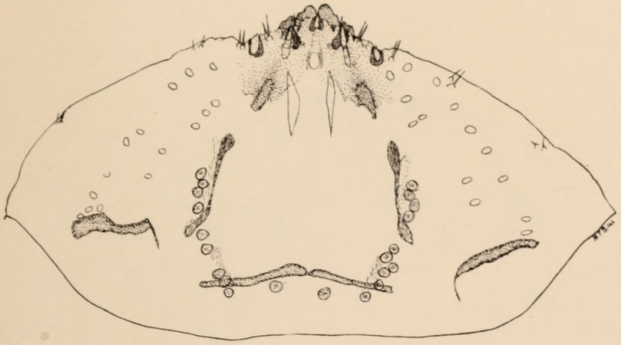
Photo April 21

Fumigating tent in operation

1

2

1 Diagrammatic figure of anal plate of scale insect showing peculiar organs
2 Aspidiotus ancylus, adult female



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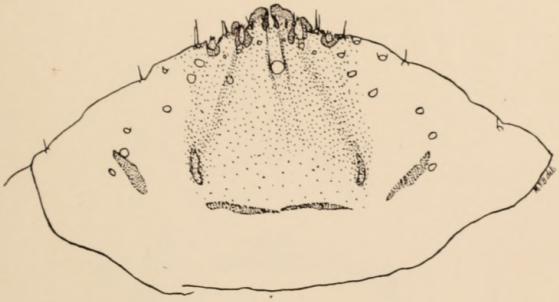
1 Aspidiotus forbesi, adult female
2 Aspidiotus perniciosus, adult female



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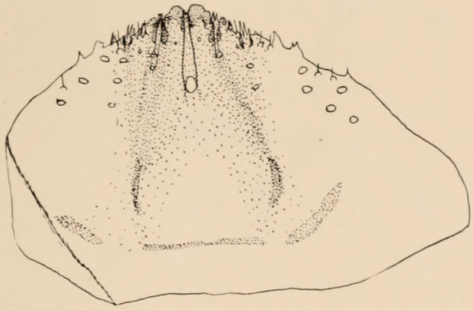

2

1 Aspidiotus forbesi, second stage
2 Aspidiotus perniciosus, second stage

Aspidiotus ostreaeformis

1

2

1 Aspidiotus ancylus, second stage
2 Aspidiotus ostreaeformis, second stage

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New York State Museum

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